USDA/STATE/EPA ASSESSMENT TEAM OF THE
NATIONAL AGRICULTURAL PESTICIDE IMPACT ASSESSMENT PROGRAM
UNITED STATES DEPARTMENT OF AGRICULTURE

+ Report by TAC
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USDA/State/EPA Captan Assessment Team

An Analysis of Current Captan Uses; Their Benefits, the Role of Alternatives, Impacts to Agriculture from Changes in Captan Use Patterns and Applicator Exposure

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INTRODUCTION

The purpose of this report is to evaluate the benefits accrued due to the use of the fungicide captan and to assess the impact of removal of this fungicide from agricultural use. This report was produced as a team effort by personnel from USDA-EPA and state landgrant universities. The team wishes to thank the many persons in other universities, industries, and agribusinesses who have so generously given their time to answer our many questions.

Captan was first introduced for agricultural use in 1954. This was the first compound developed in the Heterocyclic group which includes the fungicides folpet, captafol, glyodin and Dyrene. Because of its unique characteristics of broad spectrum activity against many groups of fungi, its low mammalian toxicity, and lack of phytotoxicity, captan use was adapted rapidly, particularily in the areas of fruit production and seed treatment.

Today nearly 30 years after its initial introduction, captan is the most widely used fungicide in the USA, with more than 12 million lbs ai being used annually. Table 1 outlines the distribution of estimated captan usage in 1979 for the USA. It is important to note that captan uses on fruit account for 57.3% of all use in the USA and that 33.0% is utilized on field and vegetable crops primarily as seed treatment materials. Another 8.9% is utilized by homeowners for control of home fruit, vegetable and ornamental problems. Other commercial uses account for less than 1% of total use.

Detailed information in this document shows the critical need for captan on nuts and pome, drupe, and small fruits. The removal of captan for use on these commercial crops would have a serious economic impact on these industries and on the cost of these commodities to the consumer. The total impact will depend largely on the continued registration of other RPARed or pre-RPARed fungicides and on the registration of new fungicide products. Of critical importance are the EBDC fungicides and captafol which are often the best alternative fungicides.

This report also details the importance of captan in the area of seed treatment for field and vegetable crops. The loss of captan would have a major economic impact. For example, it is estimated that corn yields would be reduced by 5-10% if corn producers did not use a fungicide seed treatment and had to delay planting to wait for favorable soil conditions. This delay in planting would affect nearly 50 million acres in the USA. If one assumes a yield of 100 bu/A, this loss would be nearly 0.5 billion bu of corn over 1.25 billion dollars. Similar but less dramatic losses would occur with several vegetable crops, cotton, peanuts, and small grains. Because of its unique characteristics there is at present no economically acceptable alternative to captan in this use area.

In other use areas, particularly foliar uses on vegetables, potato seed treatment and citrus sprays there are suitable alternatives for captan and removal from the market place would have a relatively small economic impact.

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Home garden uses of captan are important, primarily in the area of home fruit production. The home fruit grower has few available alternatives and would certainly be adversely affected by the removal of captan from the market place.

Another area of concern regarding the removal of captan from use is the potential adverse impact on IPM programs and on continual use of benzimidazole fungicides such as benomyl, thiabendazole, and thiophanate methyl. This is of particular concern in the area of pome and drupe fruit production.

The continued use of the valuable benzimidazole fungicides is jeopardized by the loss of captan in that without captan it is felt that fungi would rapidly develop resistance to these fungicides. Captan appears to be the best protectant fungicide to use with the benzimidazole fungicides when one considers efficacy and economics.

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Table 1. Estimated Captan Usage in the USA in 1979.

Site Used	Percent of Total Usage	Quantity of active ingredients applied (1,000's of lbs.)	Percent of Crop or Site Treated
Pome Fruits	22.9		
Apples		2,475 - 2,520	31.7 - 32.3
Pears		20 - 50	1.9 - 5.5
Stone Fruits	8.7		
Cherries		58 - 155	5.1 - 13.8
Peaches, Nectarines, Apricots		657 - 756	18.2 - 21.0
Plums, Prunes		60	6.7
Small Fruits	13.0		
Strawberries		101 - 259	70.0 - 90.0
Grapes		621 - 648	29.6 - 30.9
Brambles		132	90.0
Blueberries		420	90.0
Other Fruits	12.7		
Almonds		1,298	85.0
Citrus		125	7.0
Field Crops	19.5		
Corn, dent & sweet		1,114	100.0
Small Grains & Other field crops including peanuts		690 - 725	-
Cotton		342 - 345	80.0
Potatoes (seed treated)	9.9	807 - 1,110	48.3 - 66.4
Vegetables (foliar or seed)	3.6	350 - 400	-
Homeowner	8.9	1,000	-
Ornamental	0.4	45 - 50	-
Turf		19.6	-
Forest & Other Crops		6.0	-
(Tropical fruit &		10 - 12	-

vegetables)	
Total	100.0%

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POME FRUITS

I. Commodity Information

Apples and pears are the pome fruits discussed in this report. Production of pomes is concentrated in areas where spring and winter climates are moderate such that the wood of the trees is not killed on the coldest nights. However, the winter climate must be sufficiently cold and long to provide winter chilling to break the rest period for the buds, but not too long to prevent sufficient heat units to accumulate in summer for fruit maturation.

Apples are grown in most regions of the United States (Table 1) with about 57.6% of the production located east of the Rocky Mountains and 42.4% west of the Rocky Mountains. Percentage production by region is: Southeast, 5.4%; Mid-Atlantic, 18.4%; Northeast, 17.9%; Midwest, 15.9%; and West, 42.4%. States with major production are: Washington (30.3%), New York (13.2%), Michigan (9.8%), California (6.8%), Pennsylvania (6.2%), Virginia (6.0%), North Carolina (4.3%), and West Virginia (3.4%). In the West, per acre production is 1.5 to 2 times that in the East. Thus, about 70% of the apple acreage is located east of the Rocky Mountains where moist climates dictate much more frequent fungicide applications to control apple scab and fungal rots.

Utilization of apples produced in the East differs significantly from western apples, particularly those produced in Washington. In the eastern states, about 60% of the production is processed, either canned or pressed into juice and cider, and 40% is sold fresh market (Table 2). In Washington, over 75% of the production, or about 23% of the total U.S. apple production, is sold fresh. In California, about 78% is processed with the majority pressed for juice to make wine.

Unlike apples, pear production is concentrated west of the Rocky Mountains. USDA Crop Reporting Board data for 1977-1979 indicate 95.5% of the production is west of the Rockies and 4.5% east of the Rockies. States with pear production are: California (41.9%), Washington (30.4%), Oregon (21.9%), New York (2.2%) and Michigan (1.6%). Yields per acre are much lower in the East than the West.

II. Diseases of Pomes Controlled by Captan

Captan is registered for the control of ten diseases of apple (Table 3, first entry) and for scab of pear. Most of these diseases are very destructive and if not controlled, would severely limit apple and pear production east of the Rocky Mountains. Captan can also be used as a postharvest treatment for the control of Botrytis, Gloeosporium, and Rhizopus. Descriptions of these diseases are presented by Anderson (3), Jones (9) and Wilson and Ogawa (18).

a. Apple scab - (Venturia inaequalis) is a commercial problem in all apple production areas east of the Rocky Mountains and 10 to 15 fungicide applications are applied annually for its control. The climate in the Midwest and Northeast fruit-growing regions is

of apples grown in the Pacific Northwest

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extremely favorable for scab and some highly susceptible varieties are grown in these areas. In the Mid-Atlantic and Southeast regions, scab is usually easier to control because the varieties are less susceptible and the temperatures are often too high for many repeated secondary cycles of scab development. However, in cool wet seasons, scab can be as severe in the southern as the northern states. In the Western region, the potential for apple scab is always present. During the last 5 years scab has been more of a problem in Oregon, Washington, and Calfornia and growers typically spray two to four times a season with an eradicant type fungicide.

Fungicides are the only reliable means for control of apple scab in commercial orchards. Resistant cultivars are being developed and a few have been released for commercial testing. However, widespread use of scab resistant apple cultivars is not expected for many years and the complete replacement of well-established susceptible varieties with resistant cultivars is highly unlikely.

b. Black rot (*Physalospora obtusa*) is a disease of the fruit, leaves, and branches. In the Southeast, Mid-Atlantic, and southern states of the Midwest, fruit infections can be devastating without chemical control. Sprays for this disease are initiated at the pink stage of bud development with at least six applications required. In the northeast and northern Midwest states, this disease is not a commerical problem except in unusually warm seasons and where the pathogen has built-up in dead wood from

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a pathogen in dead wood from

fire blight infections.

c. White rot or Botryosphaeria rot (*Botryosphaeria dothidea*) is commonly referred to as Bot rot or white rot because the normal skin color is often bleached out of diseased apples. The disease is favored by warm temperatures, and is a commercial problem in the Southeast, Mid-Atlantic and southern Midwest states. Losses from this disease are often severe and fungicides are the only method of control. Timing of sprays for control of white rot is 3rd cover through 7th or 8th cover. The sprays applied for black rot may also help control white rot in years with early infections.

d. Bitter rot (*Glomerella cingulata*) is a disease of the fruit and symptoms may appear a month after bloom. The disease is a commercial problem in the Southeast, Mid-Atlantic and southern Midwest states. It does not occur in all orchards, but once established it can be very serious. Bitter rot spores are produced in great abundance on the surface of infected fruit and are spread from apple to apple by splashing rain and insects. Fungicide sprays are the main control, and to be effective, must be applied before the disease is established.

e. Sooty blotch and fly speck (*Gloeodes pomigena* and *Microthyriella rubi*) are common names of two diseases usually found occurring together on apple and pear fruit. They do little or no actual damage to the fruit, but lower market value by their presence on the surface. These diseases occur wherever apples are grown, but are generally more important in the Southeast,

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Mid-Atlantic, and southern Midwest states. Fungicides are needed from about 2nd cover through the 7th or 8th cover spray on apples and in preharvest sprays on pears.

f. Brooks fruit spot (*Mycosphaeralla pomi*) occasionally appears on fruits in late summer as small, skin-deep, greenish spots with indefinite margins. This disease is of minor importance in commercial orchards today, but, with the use of reduced or modified fungicide programs, could become important in future years. It has been reported from most of the fruit growing states east of the Rockies. Control of fruit spot depends on thorough spraying in the early cover sprays.

g. Black pox (*Helminthosporium papulosum*) appears on fruits as small, tan to black spots with definite margins. This disease is usually no problem in orchards that are well sprayed year after year with fungicides but could become important in the future with modified fungicide programs.

h. Botrytis - causes a blossom-end rot of apples early in the season and also decay of mature apple and pear fruits in cold storage. The fungus thrives on cool rainy weather and may infect the young sepals during bloom or even after blossom fall if favorable weather persists. Fungicides applied in sprays around the bloom period control this disease. Preharvest fungicide sprays also help to control decay from *Botrytis* in cold storage.

i. Bull's-eye rot - (*Pezicula malicorticis*, imperfect stage is

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Gloesporium) is often serious on apples and pears grown in Washington, Oregon, and the central and northern coastal districts of California. It is a problem on apple in some Midwestern states. Infection to fruit can occur anytime from petal fall to harvest, but susceptibility increases as harvest approaches, and infections are often not visible until the fruits are removed from cold storage. Losses to individual growers can be quite high. The disease is controlled by one to four pre-harvest applications of an effective fungicide (usually ziram or mancozeb).

j. Russet - although a physiological problem which causes surface blemishes on fruit, it is affected by many fungicides. Of the currently used fungicides on apples, captan gives consistently the best fruit finish in areas east of the Rocky Mountains where russeting is a problem.

k. Pear scab (Venturia pirina) is very similar to apple scab and occurs in pear orchards throughout the Eastern United States and sporadically on pears in the Pacific Northwest. Occasionally losses are high due to severe infection to the fruit. Usually five ot eight fungicide sprays will give good scab control in regions with heavy rainfall.

III. Use of Captan in Pome-fruit Production

a. Geographic areas of use

Nearly all of the captan is applied to apples and pears grown

east of the Rocky Mountains. This means that about 42% of the apple production and 95% of the pear production potentially never receive captan sprays because of the lack of disease pressure.

b. Amounts used

The acres of apples and pears treated with captan are unknown. Chevron Chemical Corporation, Stauffer Chemical Company, and Rohm and Haas Company representatives estimate that 2,475,000 to 2,520,000 lbs of technical captan are applied annually on 165,000-168,000 acres of apples. It is estimated that 22,221, 38,224, 56,771, and 48,112 acres are treated with captan fungicide annually in the Southeast, Mid-Atlantic, Northeast, and Midwest regions, respectively (Table 1). Thus, about 50% of the acreage in the Eastern United States might be treated each year with captan. However, because of the high yields in the west, only 28% of the total production for the United States might be treated each year. An estimated 20,000 to 58,000 lbs of technical captan are applied annually on 1,900 to 5,500 acres of pears. Most of this is used in New York, Michigan, Connecticut, and Pennsylvania.

c. Formulations of captan

The most common formulations of captan for use on pomes are 50% active ingredient wettable powders. A 80% active ingredient wettable powder formulation has limited usage for aerial application and for high concentrate spraying in ground equipment. Captan also is available as a dust and as a 4 flowable but the total amount used is quite low.

d. Application equipment, techniques, and rates

Air-blast ground equipment is the most common mode of application. Aerial application, primarily by custom applicators, is much less common and is used when sprays are needed for apple scab control on an emergency basis and the soil is too wet for use of heavy ground equipment. Ground dusters are also used in this latter situation.

In the eastern states, the amount of dilute air-blast sprays for apple is based on 400 gallons per acre (14.7 gallons per 40 feet of row space) for pruned trees between 20 and 22 feet in height planted in rows 40 feet apart (11). With modern air-blast sprayers, it is possible to reduce the amount of water per acre and tank mix the chemical at 3 to 30 times the standard dilute concentration. Today, captan is commonly applied at 6X to 10X concentration in 40 to 65 gallons of water per acre. Some high concentrate sprayers apply as low as 10 gallons of liquid per acre and aerial applications usually apply 5 gallons of liquid per acre.

Extension bulletins and pesticide labels for apples and pears give the rate of formulated material per 100 gallons of dilute spray or as amount-per-acre. If concentrate sprays are used, the rate-per-acre can be reduced by 20% from the dilute rate. In dilute sprays, 2 pounds of captan 50WP (1 lb active) per 100 gallons of spray is the maximum rate recommended for apple and pear diseases. This corresponds to 4 pounds of actual captan per acre per application. Most growers use 2.5 to 3 pounds of actual captan per acre. In the Northeast and northern Midwest states, 1.5

to 2.5 pounds of captan are applied per acre after the primary scab season. On apples, a total of 10 to 15 sprays are applied per season and on pears, 5 to 8 are applied.

IV. Exposure Hazards

The extent of personal exposure to captan during weighing of the fungicide, filling and mixing the spray tank, and applying the chemical is not known. Because growers often tank mix highly toxic insecticides with captan, protective clothing is normally worn throughout the spray operation. Once captan is applied, workers seldom enter the orchards to work except to mow the ground cover. The use of chemical thinning agents eliminates the need for hand thinning of fruit. Chevron Chemical Corporation and Stauffer Chemical Company are currently conducting experiments to determine the degree of exposure to captan in apple orchards.

V. Role of Captan in Pest Management Programs for Pome Fruits

During the last ten years, the development of fungicide resistance to benomyl and dodine and the development of new pest control strategies, such as integrated mite control, have modified captan's role in disease control programs. Some examples of the role of captan in integrated mite control and other pest management programs are described in the following section.

a. Integrated control of spider mites

The integrated control of spider mites is being accepted as a

of captan are applied per acre [illegible]

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Captan in Pest Management Programs for Zone Fruits

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[illegible] control programs. Some examples of the role of captan in

[illegible] and other pest management programs are described

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standard control practice in most apple producing states. The program involves the selective use of pesticides to control most orchards pests while conserving beneficial natural enemies for suppressing the principal mite pests which occur in commercial apple orchards. Integrated mite control programs often vary between states because different beneficials are utilized in the control program.

In Michigan, laboratory and field studies to evaluate the toxicity of fungicides to Amblyseius fallacis and Agistemus fleschneri, indicate captan is non-toxic to these principle predators (15). Benomyl, Dikar (74% mancozeb + 6% dinocap) dinocap, lime sulfur, and wettable sulfur are highly toxic to the predators if used at full rates. Therefore, when predatory mites begin to migrate into apple trees, captan, dodine, or low rates of Dikar are used for apple scab control and for maintaining the predatory mites. However, the mancozeb component of Dikar is presently under RPAR investigations and dodine usage is restricted because tolerant strains of the scab fungus have developed in New York and Michigan (7, 10, 12, 16).

In Pennsylvania, integrated mite control on apples depends largely on dinocap, or applications of low doses of a miticide, to suppress mites until the Stethorus punctum populations build to levels high enough to regulate the mite populations below economic injury levels. Captan plus low doses of a miticide at critical times were shown by Hull, Asquith, and Mowery (8) as an alternative to Dikar or dinocap for integrated mite control in Pennsylvania

[illegible] ... [illegible]
involves the selective use of pesticides to control mite
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[illegible] mite control [illegible]

when applied on an alternative middle system. Advantages cited for the alternate middle and integrated mite management programs are: 1) use of less pesticide; 2) more efficient use of time and orchard equipment; 3) use of predators in mite control; 4) possible increased populations of other parasites and predators and 5) lessen the chance of pests to develop resistance to pesticides.

Disturbing integrated biological mite control programs by cancelling uses of captan and the EBDC fungicides, thereby forcing use of benomyl or sulfur which are toxic to mite predators, would require the return to extensive use of miticides and increased problem with resistances to these miticides. With the small number of effective miticides currently registered and the slow pace of obtaining new registrations, serious mite problems could become widespread.

b. SAT programs of captafol and the use of captan

In the early 1970's captafol (Difolatan) was registered for apple scab control in the single application technique (SAT) program (6). Captafol is applied at high rates (5 gal of formulation/acre) at the green tip stage of bud development and through redistribution by rain, provides protection until early petal fall. Later the reduced single application technique (RSAT), which uses lower rates (3 gal of formulation/acre) of captafol and provides control through pink, was registered. The RSAT program is used where other fungicides are needed at pink for rust and mildew control.

Captan was evaluated extensively as one of the fungicides to

[illegible] to alleviate [illegible] this system. Additionally [illegible]

[illegible] and integrated pest management [illegible]

1) use of less pesticides, 2) more effective use of [illegible]

[illegible] 3) use of pesticides in more [illegible]

Populations of other pests [illegible]

essen the chance of [illegible]

Disturbing integrated biological [illegible] to control [illegible]

alling uses of [illegible] and the DDC [illegible]

of benomyl [illegible] which [illegible]

quire the return to extensive use of [illegible]

problem with resistance [illegible]

f effective [illegible]

[illegible]ing new registrations [illegible]

SAT programs of optical [illegible]

the early 1970's [illegible]

[illegible] control in the single [illegible]

rogr (6). Material is applied [illegible]

[illegible] the spread [illegible]

[illegible] registration by [illegible]

[illegible]. Later [illegible]

uses lower rates (3 ml of formulation [illegible]

as one [illegible] plots, was registered. The [illegible]

[illegible]

[illegible] as one of the [illegible]

use in follow-up sprays in the SAT and RSAT programs. Used in this way, captan provides good control of secondary apple scab.

c. Role of captan in fungicides resistance problems

Benomyl (Benlate) and dodine have encountered serious problems of pathogen resistance following several years of intensive use in apple and pear production, indicating that these compounds are not the ultimate solution to pome-fruit disease control. Experience so far indicates that exclusive and intensive use of fungicides, particularly relatively specific-acting fungicides, hastens the development of resistance. However, avoiding exclusive use of a fungicide requires that alternative fungicides be available for controlling the problem diseases. Limiting or preventing usage of captan, the EBDC's, captafol, and folpet would severely hinder attempts to prevent resistance against new fungicides and to cope with existing resistance problems.

d. Captan for suppressing sporulating scab lesions

When primary infections are present on 2% or more of the leaves, control for the remainder of the season is apt to be difficult. Each scab spot is capable of producing up to 100,000 spores, which can cause infection if rates and spray timing are not exact. The number of spores produced in lesions and their ability to germinate can be markedly reduced, but not completely eliminated, by some apple scab fungicides if applied at full rates in two sprays 7 days apart. Benomyl and dodine are the most effective for suppressing lesion development, sporulation, and viability of

conidia (1,2). Captan also reduces inoculum and spore germination and is the fungicide of choice where benomyl and dodine resistant apple scab exists. Cancellation of captan would make control of established infections difficult because alternative fungicides for this purpose are not available where resistance is a problem.

VI. Information on Other Registered Fungicides Used on Pomes

a. Fungicides for apples and pears

A large number of fungicides are registered for disease control on apples in the United States. These fungicides can be grouped as either standard type materials or a specialty type materials. Standard type materials are fungicides used extensively through the growing season to control several major diseases. Standard compounds used today include captan and Dikar, metiram, and mancozeb. Specialty type materials are used to control a single disease problem such as rust, powdery mildew, or apple scab. Often those materials were used extensively when first introduced but were not able to make major inroads into the apple fungicide market for more than a few years. Specialty type compounds include benomyl (Benlate), dodine (Cyprex), captafol (Difolatan), dichlone (Phygon, Quintar), zineb (Dithane Z-78), sulfurs, coppers, ferbam (Carbamate), thiram (Thylate), folpet (Phaltan), and ziram. A biref discussion of each material and its current role in disease control programs for apples follows:

1. Standard compounds

ger (1,3). Captan, also reduces [illegible] gemmina[illegible]

to the fungicide of [illegible] and dodine resistant

[illegible] exists. [illegible] would make control of

[illegible] infections [illegible] alternative fungicides for

this purpose are not available [illegible] problem.

[illegible] Other [illegible]

Fungicides for apples and [illegible]

large number of fungicides [illegible]

apples in the United States. [illegible]

standard type materials [illegible]

type materials [illegible]

wing [illegible] to control [illegible] diseases. [illegible]

ounds used today include [illegible]

ozeb. Specialty type materials are [illegible] a single

[illegible] problem such as [illegible] powdery mildew, or [illegible]

on [illegible] used [illegible]

able to make major [illegible] fungicide markets

than a few years. Specialty type [illegible]

Benlate), dodine (Cyprex), [illegible]

[illegible] dinocap (Karathane), [illegible]

[illegible] thiram [illegible]

[illegible] of each material and its [illegible] role in disease

[illegible] for apples follows:

Dikar -- is a mixture containing the active ingredients found in Dithane M-45 and Karathan (mancozeb plus dinocap). It is effective against most of the major diseases controlled by captan (Table 3) and also controls rusts and powdery mildew. Dikar has been a very useful product in integrated pest management programs since it tends to delay the buildup of injurious populations of the European red mite and does not harm the predator *Stethorus punctum*. In the northeast where pressure from apple scab in heavy, captafol (RSAT) and dichlone are sometimes used from budbreak until pre-pink, with Dikar applications starting at pink and continuing through to the pre-harvest period.

metiram -- is effective in protective schedules against most of the major diseases controlled by captan (Table 3). It also controls rusts. Where powdery mildew control is important, it is tank-mixed with sulfur, dinocap, or benomyl and provides about the same level of control as Dikar.

maneb plus zinc and manzoceb -- are effective in protective schedules against most of the major diseases controlled by captan (Table 3) and also against rust. The zinc is added to maneb to prevent phytotoxicity. Where powdery mildew control is important, it is tank mixed with sulfur, dinocap, or benomyl. In late-season sprays, these products give blotchy residues which may be too unsightly for fruits to be sold for the fresh market.

2. Specialty compounds

— is a ...

... (plus dinocap)

is effective against ... mildew or

captan (Table ...) ... powdery mildew.

... has given a ...

ment program since it tends to delay ... buildup of ...

populations of the European red mite ...

predator *Stethorus punctum*. In ...

from apple scab in ... captafol ...

sometimes used from budbreak until pre-pink, with ...

applications starting at ...

test period.

metiram -- is effective in protective ...

ost of the major diseases controlled ...

so controls rusts. Where powdery mildew control is

ant, it is tank-mixed with sulfur, ...

and provides about the same level of control as Dikar.

maneb plus zinc ion ... -- are effective in ...

edules against most of the major ...

(Table 3) and also against rust. The zinc is added to

to prevent phytotoxicity. Where powdery mildew ...

ant, it is tank mixed with sulfur, dinocap, or

... In late-season sprays, these products give ...

which may be too ...

-- benomyl -- Introduced for commercial use on apples in 1973, benomyl quickly became the dominant fungicide for the control of apple scab and powdery mildew and for certain summer diseases (Table 3). In 1975, benomyl-resistant apple scab was detected in Michigan and subsequently resistance was detected in North Carolina, Maine, New York, Virginia, Indiana, and Minnesota (10, 15). North Carolina and Michigan no longer recommend benomyl on apples because it is ineffective due to widespread resistance. Benomyl is recommended on apples in most other states east of the Rocky Mountains with the limitation that applications be restricted to critical times in the growing season and that it be tank mixed with another fungicide as stated on current benomyl labels. In the Pacific Northwest, benomyl is recommended as a post-harvest treatment only for Botrytis, Penicillium, and Gloeosporium to reduce resistance problems in the packing house and storage. Resistance in Penicillium is a problem in Michigan, Virginia, New York, Washington, and Oregon, and has resulted in losses from the blue mold disease in stored fruits (4, 14, 19). Benomyl cannot be considered an alternative to captan because of the resistance problem.

captafol -- is used on apples as a single spray at the green tip stage of bud development to control scab for 3 to 6 weeks, depending on the application rate. If applied after green tip, captafol will cause fruit russet, even at low rates. Timing of sprays to avoid injury in southern areas is difficult

in years when unusually warm weather occurs at green tip. This chemical can produce a dermal allergic response in some people. Captafol is currently used as an alternative to captan, particularly in the Northeast and northern Midwest, for early season scab control. Because of its limited disease control spectrum (Table 3), its phytotoxicity problems, and the potential of some people to suffer allergic dermatitis from its use, captafol cannot be considered as a general replacement for captan on apples. Moreover, it is not registered for use in the West and it is not registered on pears.

copper compounds -- are used primarily for the control of fire blight on apple and pears. They will help control apple scab but are too weak to give dependable control. They are also highly phytotoxic and will severely russet apples and pears when applied under cool wet conditions. There are also many compatibility problems with the coppers.

dichlone -- is used primarily as an emergency eradicant spray for scab, particularly in orchards with benomyl or dodine resistance, and where captan would no longer be effective as an eradicant treatment. Dichlone is effective for eradication for about 24 hours longer than captan. Applications are restricted to the period between bud-break and first cover because of possible adverse effects on fruit size, maturity, and bud set. Dichlone may cause foliar and fruit injury if low or high temperatures exist at or a few days after application. Because of its limited disease control spectrum (Table 3) and the high{

potential for phytotoxicity, dichlone should not be considered as an alternative compound for captan. It also breaks down rapidly under high temperature conditions, limiting its usefulness in southern areas.

dodine -- was used extensively for apple scab control in the Northeast and northern Midwest regions following its commercial introduction in about 1958. Today dodine usage is low because of widespread resistance of the apple scab fungus (7,10,12,16). Resistant strains were detected in New York in 1968 and in Michigan in 1975. Dodine resistance is also a problem in Canada. Because of its limited disease control spectrum (Table 3) and resistance problems, dodine cannot be considered a replacement for captan. It is not registered on pears east of the Rocky Mountains, but it is registered west of the Rockies and is used extensively where pear scab is a problem.

ferbam -- is tank mixed with apple scab fungicides during the period from pink to first cover (4 to 5 applications) for the control of rust diseases. Its use is restricted to areas where rust diseases are a problem. Frequently, one of the EBDC fungicides or thiram is used in preference to ferbam for rust control. When ferbam was first introduced, it was used to control apple scab at 2 to 2.5 times the rust control rate. Control of fruit scab was often inadequate, as demonstrated again in recent studies (20). Moreover, fruit of Rome, Red Delicious, Stayman, and Golden Delicious sprayed with ferbam

often have enlarged lenticels and ferbam sprayed Stayman apples are cracked more extensively than those sprayed with captan or folpet. Ferbam, if substituted for captan for scab control, would increase disease losses and decrease fruit quality because of poor finish. In late-season sprays, ferbam gives blotchy residues which may be unsightly and may interfere with good coloration of the fruit.

folpet -- controls the same major diseases as captan, has the same incompatibility problems as captan, but is more phytotoxic than captan. Because of phytotoxicity, folpet is not suggested for use on apples before the fourth cover spray, except in the Southeast region where it can be used throughout the season. It is often used late in the season because it is highly effective against the summer diseases.

sulfurs -- sulfur compounds were the main fungicides used for apple disease control prior to the organic fungicide era. Rates of 400 lbs of sulfur/acre/season were not uncommon in severe disease years. Control with the sulfurs was mediocre and they were phytotoxic. Today, sulfurs are used at low rates in tank mixtures with scab fungicide for powdery mildew control. High rates are avoided because they interfere with biological mite control and can cause russeting problems.

thiram -- is tank mixed with apple scab fungicides during the period from pink to first cover (4 to 5 applications) for the control of rust diseases. It is only moderately effective against scab at a rate twice that used for rust control. It is

[illegible] and Ferbam [illegible]

[illegible] more extensively than those sprayed with captan or folpet. Ferbam, if substituted for captan for scab control, would increase disease leaves and decrease fruit quality because of poor finish. In late-season sprays, ferbam gives blotchy red fruit which may be [illegible] poor coloration of the fruit.

Folpet -- controls the same major diseases as captan, has the same inaccessibility problems as captan but is more phyto-toxic than captan. Because of phytotoxicity, folpet is not suggested for use on apples before [illegible] except in the Southeast region [illegible] the season. It is often used late in the season because it is highly effective against the summer diseases.

Sulfurs -- Sulfur and copper were the main fungicides used for apple disease control prior to the organic fungicide era. [illegible] of 800 lbs of sulfur/acre/season were not uncommon in disease years. Control with the sulfurs was mediocre and they were phytotoxic. Today, sulfurs are used [illegible] in tank mixtures with other fungicides for powdery mildew. High rates are avoided because they interfere with mite control and can cause russeting problems. [illegible] is tank mixed with apple scab fungicides [illegible] from pink to first cover (4 to 5 applications) for [illegible] of rust diseases. It is only [illegible] so that [illegible]

a good substitute for ferbam on varieties subject to fruit russet by ferbam or where visible residues are important. It is weaker than captan for the control of fruit scab and fruit rot diseases.

zineb -- has not proven effective enough against apple scab to justify its use in early season sprays. It has a somewhat longer residual life than captan and is often substituted for or combined with captan in one or two late cover sprays for control of sooty blotch, fly speck, and late summer rots. By using zineb rather than captan in late cover sprays, captan usage is often reduced by one application. It is used primarily in states south of Michigan and New York.

ziram -- is used for the control of bull's-eye rot. Captan is an alternative. Benomyl, although effective, is not considered an alternative because it could create resistance problems in other important pathogens.

b. Impact of fungicide cancellations

Apples -- Possible alternative disease control programs were developed for impact analysis in the event the use of captan was cancelled. Because the complex of diseases to be controlled varies between regions, programs were developed for four regional groupings based on their problems. Benomyl and dodine were not included as alternative fungicides because of problems with resistance. In areas where resistance has not been encountered, it is anticipated resistance will develop within a few years if these fungicides are used for disease control. Hypothetical programs

seed production from Germany [illegible]

by [illegible] or [illegible] [illegible] [illegible] [illegible]

then chosen for [illegible] control [illegible] [illegible] and fruit

diseases.

Alone — [illegible] not known. [illegible] [illegible] [illegible]

to justify the use in [illegible] [illegible]

longer species [illegible] [illegible]

or combined with [illegible]

control of [illegible] [illegible]

with other rates. [illegible]

usage is often reduced [illegible] application [illegible]

primarily in states [illegible]

None - is well [illegible]

[illegible] alternative. Benefit [illegible] [illegible] [illegible]

considered an alternative [illegible] [illegible]

problems in other important [illegible]

Impact of Function generalizations

-- Possible alternative [illegible]

[illegible] for impact analysis in the overall [illegible]

Because the complex of [illegible]

[illegible], programs were developed for [illegible] regional

[illegible] on their problems. Benefit and [illegible] were

[illegible] because of [illegible]

[illegible] has not been [illegible]

based on benomyl are no longer viable because benomyl is no longer registered for use alone on apples.

Northeast and northern Midwest: Includes states in the Northeast region plus Michigan, Minnesota, and Wisconsin where apple scab is the major disease and powdery mildew is minor. Excepted are areas in some states, like the Hudson Valley region of New York, where rusts are also a problem.

In these states, the necessity of captan lies in its value to control apple scab where resistance to benomyl and/or dodine has been encountered. Confirmed resistance to benomyl and/or dodine is widespread in these states. Captan is used exclusively through the growing season or in follow-up sprays in SAT or RSAT programs with captafol (Table 4). The EBDC's are also used as outlined in programs 3, 4, 7, and 8.

Cancellation of captan would increase the use of the EBDC's and of captafol in nearly equally effective fungicide spray programs. If captafol and captan were cancelled, the EBDC's would become the main fungicides used along with increased use of dichlone in the prebloom period.

Cancellation of captan and the EBDC's would increase captafol usage for early season scab control and thiram or ferbam in follow-up sprays (programs 5 and 6). Additional research would be required for determining the effectiveness of the follow-up spray programs and their compatibility with IPM programs. Ferbam (program 6) would give reduced fruit finish in years with cool wet weather between petal fall and second cover and would increase

[illegible], ferbam) are no longer viable [illegible] larger

[illegible] for use alone on apples.

Northeast and North Central: [illegible]

east region plus [illegible], Minnesota, and [illegible]

is the major disease and European red mite is minor. [illegible]

in some states, like the Hudson Valley region of New

York, where rusts are also a problem.

In these states, the necessity of captan lies in [illegible]

[illegible] apple scab where resistance to benzimidazole [illegible]

[illegible] encountered. Confirmed resistance to [illegible]

[illegible] in these states. Captan [illegible] exclusively through [illegible]

[illegible] season or in follow-up sprays to

captafol (Table 4). The [illegible] are also used as [illegible]

programs 3, 4, 7, and [illegible]

Cancellation of captan would increase the use of the [illegible]

of captafol in nearly equally effective [illegible]

captafol and captan were cancelled, the [illegible] would [illegible]

[illegible] used along with increased [illegible] of dithiocarbamates in the

period.

[illegible] of captan and [illegible] would increase [illegible]

for early season scab control and [illegible] or ferbam in [illegible]

[illegible] (programs 1 and 6). Additional research would be

[illegible] the effectiveness of the following spray

[illegible] compatibility with IPM programs. [illegible]

[illegible] fruit [illegible] in years with [illegible]

[illegible] occurs only [illegible] would [illegible]

problems with visible residues at harvest. Current supplies of captafol, thiram, and ferbam are too low to provide the quantities of fungicide needed by the apple industry.

Cancellation of captan, captafol, and the EBDC's on apples would create chaos in the apple industry. Level of control and dependability would decline with few materials. Overall control cannot be fully assessed but would be sufficiently low to result in unstable production. Equally effective alternative fungicide spray programs would simply not be available should the registration of captan, captafol, and the EBDC's for apples be cancelled.

Selected areas of Northeast, Midwest, and Mid-Atlantic regions: Apple scab, rust and powdery mildew control is critical and increased attention must be given to the control of summer diseases. Currently, the EBDC's are used extensively in these areas because they provide rust and scab control, are compatible with most insecticides and fungicides, and fit well with integrated biological control of European red mites.

The importance of captan in this region is its value as an alternative to the EBDC's, and integrated biological control programs for European red mites have been developed using captan and dinocap (Table 5) or captan and low dosages of miticides if dinocap is not used for powdery mildew control. In captan programs, thiram or ferbam are added for rust control in sprays from pink to first cover at about one-half the rate these compounds are used for apple scab control.

Cancellation of uses of captan and the EBDC's would create

major problems in this region because equally effective alternative fungicide spray programs are not available. Captafol would have limited value for early season scab control because it does not control rust diseases. Thiram and ferbam would be the main fungicides available (Table 5, programs 1, 2, 5 and 6). In one test, control of scab was poor when thiram was used after captafol (21). Yields and fruit quality would be reduced due to increased levels of diseases and fruit finish problems with ferbam. Integrated biological mite control programs would need to be re-examined.

Southeast and areas in the Mid-Atlantic and southern Midwest regions: Includes states in the southeast region plus Virginia, Missouri, Kentucky, and southern Illinois and Indiana where apple scab rusts, powdery mildew, and several summer diseases are all economically important problems. Because of heavy disease pressure in summer, high fungicide rates are used through the cover spray period (Table 6).

In these states, the importance of captan is its value as an alternative to the EBDC's (programs 3 and 4) for the control of apple scab, black rot, bitter rot, white rot, sooty blotch and fly speck. Captafol is not an alternative because it provides early season scab control only and cannot be used later in the season because of severe russetting problems.

Folpet (program 7) is a possible alternative but may cause occasional fruit finish problems and leaf spotting which could lead to increased black rot. In the economic analysis report for the EBDC's (17), fruit losses from bitter rot were estimated at 30

In this region, because [illegible]

yield [illegible] may [illegible] For early season [illegible] rust diseases. [illegible] ble (Table 5, programs 1, 2, [illegible]) [illegible] was [illegible] yields and [illegible] quality would be raised [illegible] ases and fruit [illegible]. [illegible] cide control programs [illegible]

[illegible] and sugar on the [illegible]. Includes states in the [illegible] Kentucky, and [illegible] mulch, powdery mildew, [illegible] cally important problems. [illegible] er, high fungicide [illegible] (Table 6).

In these states, the importance of [illegible] native to the EBDC's (programs 2 [illegible]) black rot, bitter rot, [illegible]. Captafol is not an alternative [illegible] ab control only and [illegible] severe russetting problems.

[illegible] 7) is a [illegible] [illegible]

percent when folpet was used compared to 2 percent for Dikar. Thus, a loss of 28 percent or about 6.3 million 42-pound units of apples is estimated to occur with a folpet program. Grading costs would increase this loss.

Cancellation of uses of captan, captafol, folpet, and the EBDC's would force the use of thiram and ferbam (programs 1 and 2). These compounds are weak against the complex of pests in this region (Table 3) and losses would be high. New orchards would not be established in the region but existing orchards would be maintained for a few years. Within ten years, it is estimated commercial production in the southeast would be abandoned unless new effective fungicides were introduced.

West -- Captan is an alternative to ziram for bull's-eye rot control on apple and pears. Currently, ziram is used almost exclusively to control this disease but if ziram were no longer available and the EBDC uses were cancelled, captan would become the main fungicide for bull's-eye rot control provided there were no problems with phytotoxicity. Benomyl is not considered as an alternative because it is needed for postharvest disease control.

Pears -- Ferbam is the main alternative to captan for the control of pear scab in the East. Other chemicals that are sometimes used for pear scab are zineb, ziram, and mancozeb. Dodine is used in the West but not registered for use on pears in the East. Benomyl is also effective but is combined with captan to delay problems with resistance. Ziram is the main fungicide for bull's-eye rot control in the West. Preharvest sprays of benomyl are

[illegible] was used [illegible] for [illegible].

[illegible] of 58 percent or about 3.2 million [illegible]

[illegible] is estimated to occur [illegible]. [illegible]

[illegible] increase this [illegible]

Cancellation of [illegible], and the

[illegible] would [illegible] and 21.

[illegible] compounds [illegible]

[illegible] (Table 3) and losses would [illegible] would not

established in the region but [illegible] would be

[illegible] for a few years. Within [illegible]

[illegible] production in the southeast would [illegible]

[illegible] fungicides [illegible]

[illegible] -- Captan is an alternative [illegible]

on apple and pears. [illegible]

[illegible] to control this disease [illegible]

[illegible] and the EBDC [illegible] would [illegible] the

[illegible] fungicide for bull's-eye rot control

[illegible] with phytotoxicity. [illegible] is not [illegible]

[illegible] because it is [illegible]

Pear -- Ferbam is the only alternative to [illegible] for the

[illegible] of pear scab in the East. Other [illegible]

[illegible] pear scab are [illegible]

[illegible] but not registered for use on pears in the East.

[illegible] is also effective but is combined with captan [illegible]

with [illegible]. Ziram is the main fungicide for [illegible]

[illegible] the West. [illegible]

avoided in the West to maintain it as an effective postharvest treatment for blue mold. Cancellation of captan uses would eliminate the main alternative to the EBDC fungicides for pear scab and bull's-eye rot control. Losses from postharvest decay problems would be particularly high in the West because benomyl resistant strains of *Penicillium* (blue mold) have developed and the industry has shifted to a combination of benomyl plus captan.

VII. Summary

Rejection by public agencies of the use of captan on apples would result in increased and nearly exclusive use of EBDC fungicides. Captafol use would increase in the Northeast and northern Midwest for early season apple scab control, but EBDC fungicides would be used for the remainder of the season. Usage of benomyl and dodine would also increase, then decline because of fungicide resistance. Cancellation of captan would deny an effective chemical which may be needed for localized pest problems and for preventing resistance problems in the future.

Cancellation of captan and the EBDC's would force the use of older less effective fungicides. Total quantities of chemical applied per acre annually would increase while the quantity and quality of apple crops would decline. Control of summer diseases would be particularly difficult. Fruit russetting and visible residues would increase as problems. This action would make obsolete certain research that has gone into the development of current, successful programs based on the

the West to maintain it as an effective postharvest
tment for blue mold. Cancellation of captan uses would
the main alternative to the EBDC fungicides for pear decay
ll serve for control. Losses from postharvest decay
d be particularly high in the West because benomyl resistant
of Penicillium (blue mold) have developed and the industry
s shifted to a combination of benomyl plus captan...

ection by public agencies of the use of captan on apples would
ult in increased and nearly exclusive use of EBDC fungicides.
ateful use would increase in the Northeast and northern Midwest for
season apple scab control, but EBDC fungicides would be used for
remainder of the season. Usage of benomyl and dodine would
, then decline because of fungicide resistance. Cancellations of
an would deny an effective chemical which may be needed for
ltiese pest problems and for preventing resistance problems in the

Cancellation of capta and the EBDC's would force the use of other
effective fungicides. Total quantities of chemical applied per
y would increase while the quantity and quality of apple
would decline. Control of summer diseases would be partially
ults. Fruit russeting and visible residues would increase as
This action would make chemical control research that was
nto the development of current, successful programs used in the

use of highly effective broad spectrum fungicides. Some techniques of IPM such as alternative-row middle spraying with reduced rates or use of after-infection control of apple scab would no longer be possible. IPM programs based on the interaction between natural enemies and captan or EBDC fungicide would have to be re-examined and could prove expensive to growers if alternative IPM strategies could not be developed quickly. The costs associated with pest upset potential, resistance potential, etc., should be estimated along with the direct costs of increased fungicide usage and reduced fruit quality and yields in the costs/benefits analysis.

Table 1. Apple production and distribution in the United States.

Region and State	Average annual production 42-lb equivalents 1/ (1,000 units)	Percentage production	Estimated acreage apples 2/	Estimated acreage treated with captan 3/ Percent	Amount
Southeast					
North Carolina	7,492	4.28			
Georgia	627	0.36			
South Carolina	651	0.37			
Tennessee	222	0.13			
Arkansas	476	0.27			
Total	9,468	5.41	32,648	65.0	21,221
Mid-Atlantic					
Pennsylvania	10,833	6.19			
Virginia	10,476	5.99			
West Virginia	5,952	3.40			
New Jersey	2,698	1.54			
Maryland	1,905	1.09			
Delaware	325	0.19			
Total	32,189	18.40	100,570	38.0	38,224
Northeast					
New York	23,175	13.24			
New Hampshire	1,397	0.80			
Vermont	1,151	0.66			
Massachusetts	2,341	1.34			
Connecticut	1,119	0.64			
Rhode Island	131	0.07			
Maine	2,008	1.15			
Total	31,322	17.90	97,881	58.0	56,771
Midwest					
Michigan	17,222	9.84			
Illinois	2,436	1.39			
Ohio	2,460	1.41			
Missouri	1,333	0.76			
Indiana	1,540	0.88			
Kentucky	460	0.26			
Wisconsin	1,397	0.80			
Minnesota	483	0.28			

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Kansas	325	0.19			
Iowa	249	0.14			
Total	27,905	15.95	96,224	50.0	48,112
Total (East of Rockies)	100,884	57.66	327,343	50.2	164,328
West					
Washington	53,024	30.30			
California	11,826	6.76			
Oregon	3,405	1.95			
Idaho	2,619	1.50			
Colorado	1,714	0.98			
Utah	1,055	0.60			
New Mexico	444	0.25			
Total	74,087	42.34	153,707	2.0	3,074
Total U.S.	174,974		481,050	35.0	

1/ Three-year averages (1977-1979), Statistical Reporting Service, USDA Noncitrus Fruit and Nuts - 1979 Annual Summary FrNt1-3 (80). Data from Table on page 8.

2. Assumes 290 units/acre for southeast and midwest regions, 320 units/acre for mid-Atlantic and northeast regions and 482 units/acre for states in western region.

3/ Estimated by the Biological Assessment team. Assumes 2 to 4 pounds of captan per acre per application and 4 to 6 treatments per year.

Table 2. Utilization of commercial apple production in the eight major production states and for the total United States.

State	Utilization (%) Fresh	Utilization (%) Processed	Processed Utilization (%) Canned	Processed Utilization (%) Juices & Cider	Processed Utilization (%) Frozen	Processed Utilization (%) Other
East of Rockies						
New York	39.6	60.4	44.9	38.1	7.2	9.8
Michigan	39.4	60.6	29.4	42.8	14.5	13.3
Pennsylvania	37.8	62.2	63.3	29.9	2.9	4.3
Virginia	29.3	70.7	59.5	35.8	-	4.7
North Carolina	51.9	48.1	33.0	61.2	-	5.8
West Virginia	36.9	64.0	56.0	34.0	5.3	4.7
Average	38.9	61.1	47.7	40.3	4.9	7.1
West of Rockies						
Washington	77.5	22.5				
California	21.9	78.1		47.3		
Total U.S. Utilization	56.5	43.5	37.2	44.7	6.0	6.1

1/ Two-year averages (1977-1978), extracted from Statistical Reporting Service, USDA, Noncitrus Fruit and Nuts - 1979 Annual Summary FrNt1-3 (80). Data from pages 9-12.

Table 3. Relative effectiveness of tree-fruit fungicides against the six major diseases and four minor diseases controlled by captan.

A = captan (captan 50W, Orthocide)

B = benomyl (Benlate 50W) 5/

C = dodine (Cyprex 65W)

D = captafol (Difolatan 4 EC) 6/

E = dichlone (Phygon)

EBDC's

F = metiram (Polyram)

G = dikar (Dithane M-45 + Karathane)

H = mancozeb/maneb + zinc (Dithane M-45, Manzate-D, Dithane M-22 special)

I = zineb (Dithane Z-78)

Sulfur's

J = lime sulfur

K = wettable sulfur/sulfur paste

L = ferbam (Carbamate)

M = thiram (Thylate)

N = folpet (Phaltan)

O = coppers

Fungicide	Major Diseases: Apple scab Primary	Apple scab Secondary	Black Rot (Fruit and foliage)	Bitter Rot	Bot Rot or White rot	Sooty Blotch	Fly speck	Minor Diseases: Botrytis	Black pox	Brook's fruit rot	Bull's eye rot 4/
A.	+++	+++	+++	+++	+++	++	++	(+)3/	(+)	(+)	(+)
B.	++++1/	++++	NR	NR	NR7/	++++	++++	(+)	NR	NR	(+)
C.	++++	++++	NR	NR	NR	NR	NR	NR	NR	NR	NR
D.	++++	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
E.	+++	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
F.	+++	+++	+++	++++	NR	+++	+++	NR	NR	NR	NR
G.	+++	+++	+++	++++	NR	+++	+++	NR	NR	NR	NR
H.	+++	+++	+++	++++	+++	+++	+++	NR	NR	NR	(+)
I.	++	++	++	++	++	+++	+++	NR	NR	(+)	NR

J.	++		NR	NR	NR	NR	NR				
K.	+	+	NR	NR	NR	NR	NR				
L.	++	+	+2/	++	NR	+++	+++			(+)3/	
M.	++	+	+	++	+2/	++	++	NR	(+)3/	(+)3/	NR
N.	+++	+++	+++	+++	+++	+++	+++	NR	NR	(+)3/	NR
O.	+	+	NR	NR	NR	NR	NR	NR	NR	NR	NR

1/ Ratings + = poor, ++ = fair, +++ = good, ++++ = excellent, NR = not registered for this disease or not recommended by manufacturer.

2/ Registered but not considered effective by many extension personnel.

3/ Registered but not rated for effectiveness.

4/ Problem primarily on West coast.

5/ Manufacturer only recommends in combination with other fungicides because resistance is widespread.

6/ East of the Rockies only.

7/ Bot rot control is not included on current benomyl labels, but benomyl is highly effective and is recommended for bot rot control in several states.

Table 4. Apples in Northeast and Northern Midwest regions: Hypothetical disease control programs for captan and the alternatives to replace captan if it is cancelled. Different assumptions are made relative to the availability of alternative fungicides. Programs are for locations where apple scab control is critical, where rust diseases are not a problem, where the need for mildew control is minimal, and where benomyl and dodine cannot be used because of fungicide resistance.

Table 4A.

Fungicides Applied	April 1	April 2	April 3	April 4	May 1	May 2	May 3	May 4	June 1	June 2	June 3	June 4	July 1	July 2	July 3	July 4	August 1	August 2	August 3	August 4
	ST 1/		GT	HIG	TC	P	BL	PF	1C		2C		3C		4C		5C		6C	
									pounds/acre of formulation											
captan 50W			8	8	8	8	8	8	6		4		4		4		4		4	
dinocap 25W 2/					2	2	2	2												
Alternatives																				
Assumption 1 - folpet, captafol, and EBDC's not available																				
thiram 65W	8	8	8	8	8	8	8	8	8		6		6		4		4		4	
dinocap 25W					2	2	2	2												
ferbam 76W 3/	8	8	8	8	8	8	8	8	8		6		6		4		4		4	
dinocap 25W					2	2	2	2												
Assumption 2 - EBDC's available but not captafol or folpet																				
dichlone 50W 4/			2	2																
Dikar 80W					8	8	8	8	8		6		6		4		4		4	
dichlone 50W 4/			2	2																
Polyram 80W					8	8	8	8	8		6		6		4		4		4	
dinocap 25W						2	2	2	2											
Assumption 3 - captafol available but not EBDC's or folpet																				
captafol (SAT)			5 gal																	
thiram 65W								8	8		6		6		4		4		4	
dinocap 25W								2	2		2		2							
captafol (SAT)			5 gal																	
ferbam 76W								8	8		6		6		4		4		4	
dinocap 25W								2	2		2		2							
Assumption 4 - captafol and EBDC's available but not folpet																				
captafol (SAT)			5 gal																	
Dikar 80W								8	8		6		6		4		4		4	

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captafol (SAT)	5 gal							
Polyram 80W		8	8	6	6	4	4	4
dinocap 25W		2	2	2	2			

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[illegible]

[illegible]

dinocap 25W	4	8	NA	20.32	-	Very Poor
	--			-------		
	8		Total	$177.82		

Assumption 4 - captafol and EBDC's available but not folpet

captafol (SAT)	1	5	5.0	$107.50	$107.50	Very Good
Dikar 80W	7	40	32.0	65.60	52.48	to
	--			-------	-------	Excellent
	8		Total	$173.10	$159.98	
captafol (SAT)	1	5	5.0	$107.50	$107.50	Very Good
Polyram 80W	7	40	32.0	64.00	51.20	to
dinocap 25W	4	8	6.4	20.32	16.26	Excellent
	--			-------	-------	
	8		Total	$191.82	$174.96	

1/ ST = silver tip; GT = green tip; HIG = half-inch; TC = tight cluster; P = pink; BL = bloom; PF = petal fall; and C = cover sprays.

2/ Dinocap (Karathane) used for powdery mildew control only.

3/ For processing varieties only.

4/ Dichlone (Phygon) for apple scab control. It is used at the 2 lbs/acre for after-infection control or at the 1 lb/acre rate with another fungicide at half rate on a protectant schedule.

5/ Prices per pound or gallon quoted by a large Michigan distributor on 5/2/80 as follows: captan - $1.53; dinocap - $2.54; ferbam - $1.25; thiram - $1.35; Dikar - $1.64; Polyram - $1.60; dichlone - $4.70; captafol - $21.50; and folpet - $2.00.

6/ Price not considered in acceptibility rating.

7/ The fungicides are applied as tank mixtures wherever possible.

8/ Assume sprays are applied concentrate rather than dilute. Further saving may be possible with alternate middle system and extending intervals during dry weather.

Table 5. Apples in selected areas of Northeast, Midwest, and Mid-Atlantic regions: Hypothetical disease control programs for captan and the alternatives to replace captan if it is cancelled. Different assumptions are made relative to the availability of alternative fungicides. Programs are for locations where control of apple scab, rust and powdery mildew is critical and where benomyl and dodine cannot be used because of fungicide resistance.

Table 5A.

Fungicides Applied	April 1 ST	April 2 1/	April 3 GT	April 4 HIG	May 1 TC	May 2 P	May 3 BL	May 4 PF	June 1	June 2 1C	June 3	June 4 2C	July 1	July 2 3C	July 3	July 4 4C	August 1	August 2 5C	August 3	August 4 6C
							pounds/acre of formulation													
captan 50W			8	8	8	8	8	8		6		4		4		4		4		4
dinocap 25W 2/					2	2	2	2		2		2		2		2				
thiram 65W 3/						4	4	4		4										
or																				
ferbam 76W 3/ (processing varieties only)						3	3	3		3										
Alternatives																				
Assumption 1 - folpet, captafol, and EBDC's not available																				
thiram 65W		8	8	8	8	8	8	8		8		6		6		4		4		4
dinocap 25W					2	2	2	2		2		2		2		2				
ferbam 76W*		8	8	8	8	8	8	8		8		6		6		4		4		4
dinocap 25W					2	2	2	2		2		2		2		2				
*for processing varieties only																				
Assumption 2 - EBDC's available but not captafol or folpet																				
dichlone 50W 4/			2	2																
Dikar 80W					8	8	8	8		8		6		6		6		4		4
dichlone 50W			2	2																
Polyram 80W					8	8	8	8		8		6		6		6		4		4
dinocap 25W					2	2	2	2		2		2		2		2				
Assumption 3 - captafol available but not EBDC's or folpet																				
captafol (RSAT)			3 gal																	
thiram 65W						8	8	8		8		6		6		4		4		4
dinocap 25W						2	2	2		2		2		2		2				

captafol (RSAT)	3 gal									
ferbam 76W		8	8	8	8	6	6	4	4	4
dinocap 25W		2	2	2	2	2	2	2		

Assumption 4 - captafol and EBDC's available but not folpet

captafol (RSAT)	3 gal									
Dikar 80W		8	8	8	8	6	6	6	4	4
captafol (RSAT)	3 gal									
Polyram 80W		8	8	8	8	6	6	6	4	4
dinocap 25W		2	2	2	2	2	2	2		

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Table 5B.

Fungicides Applied	Total Number Sprays	Fungicide/Season No Pest Management	Fungicide/Season With Pest Management	Total Fungicide Costs /5 No Pest Management	Total Fungicide Costs /5 With Pest Management 8/	Relative Commercial Acceptibility of Program 6/
captan 50W	12	74	59.2	$113.22	$ 90.58	
dinocap 25W 2/	8	16	12.8	40.64	32.51	Very Good
thiram 65W 3/	4	16	12.8	21.60	17.28	to
or	--			-------	-------	Excellent
ferbam 76W 3/	12		Total	$175.46	$140.37	
(processing	4	12	9.6	15.00	12.00	
varieties	--			-------	-------	
only)	12	Total without thiram		$168.86	$135.09	

Alternatives

Assumption 1 - folpet, captafol, and EBDC's not available

thiram 65W	13	88	NA	$118.80	-	None to
dinocap 25W	8	16	NA	40.64	-	Very Poor
	--			-------		
	13		Total	$159.44		
ferbam 76W*	13	88	NA	$110.00	-	None to
dinocap 25W	8	16	NA	40.64	-	Very Poor
	--			-------		
	13		Total	$150.64		

*for processing varieties only

Assumption 2 - EBDC's available but not captafol or folpet

dichlone 50W 4/	2	4	3.2	$18.80	$ 15.04	Very Good
Dikar 80W	10	66	52.8	108.24	86.59	to
	--			-------	-------	Excellent
	12		Total	$127.04	$101.63	
dichlone 50W	2	4	3.2	$ 18.80	$ 15.04	
Polyram 80W	10	66	52.8	105.60	84.48	Very Good
dinocap 25W	8	16	12.8	40.64	32.51	to
	--			-------	-------	Excellent
	12		Total	$165.04	$132.03	

Assumption 3 - captafol available but not EBDC's or folpet

captafol (RSAT)	1	3(gal)	NA	$ 64.50	-	None to
thiram 65W	9	56	NA	75.60	-	Very Poor
dinocap 25W	7	14	NA	35.56	-	

	10		Total	$175.66		
captafol (RSAT)	1	3	NA	$ 64.50	-	None to
ferbam 76W	9	56	NA	70.00	-	Very Poor
dinocap 25W	7	14	NA	35.56	-	
	10		Total	$170.06		

Assumption 4 - captafol and EBDC's available but not folpet

captafol (RSAT)	1	3	3.0	$ 64.50	$64.50	Very Good
Dikar 80W	9	58	46.4	95.12	76.10	to
						Excellent
	10		Total	$159.62	$140.60	
captafol (RSAT)	1	3	3.0	$ 64.50	$64.50	Very Good
Polyram 80W	9	58	46.4	92.80	74.24	to
dinocap 25W	7	14	11.2	35.56	28.45	Excellent
	10		Total	$192.86	$167.19	

1/ ST = silver tip; GT = green tip; HIG = half-inch green; TC = tight cluster; P = pink; BL = bloom; PF = petal fall; and C = cover sprays.

2/ Dinocap (Karathane) used for powdery mildew control only.

3/ Thiram and ferbam used primarily for control of rust diseases.

4/ Dichlone (Phygon) for apple scab control. It is used at the 2 lbs/acre rate for after-infection control or at the 1 lb/acre rate with another fungicide at half rate on a protectant schedule.

5/ Prices per pound or gallon quoted by a large Michigan distributor on 5/2/80 as follows: captan - $1.53; dinocap - $2.54; ferbam - $1.25; thiram - $1.35; Dikar - $1.64; Polyram - $1.60; dichlone - $4.70; captafol - $21.50; and folpet - $2.00.

6/ Price not considered in acceptibility rating.

7/ The fungicides are applied as tank mixtures wherever possible.

8/ Assume sprays are applied concentrate rather than dilute. Further saving may be possible with alternative middle system and extending intervals during dry weather.

Table 6. Apples in Southeast, Mid-Atlantic, and Southern Midwest regions: Hypothetical disease control programs for captan and the alternatives to replace captan if its registration is cancelled. Different assumptions are made relative to the availability of alternative fungicides. Control programs are for locations where apple scab, rusts, powdery mildew, black rot, Botryosphaeria (white) rot, bitter rot, sooty blotch and fly speck are critical and where benomyl and dodine cannot be used because of fungicide resistance.

Table ЬA.

Fungicides Applied	March		April				May			June		July		August
	1 2 3	4	1	2	3	4	1	2 3	4	1 2 3	4	1 2 3	4	1 2 3 4
	ST 1/	GT	HIG	TC	P	BL	PF	1C	2C	3C	4C	5C	6C	7C
						pounds/acre of formulation								
captan 50W		8	8	8	8	8	8	8	8	8	8	8	8	8
dinocap 25W 2/				2	2	2	2	2	2	2	2			
thiram 65W 3/					4	4	4	4						
or														
ferbam 76W 3,4/					3	3	3	3						
Alternatives														
Assumption 1 - folpet, captafol, and EBDC's not available														
thiram 65W	8	8	8	8	8	8	8	8	8	8	8	8	8	8
dinocap 25W				2	2	2	2	2	2	2	2			
ferbam 76W 4/	8	8	8	8	8	8	8	8	8	8	8		8	8
dinocap 25W				2	2	2	2	2	2	2	2			
Assumption 2 - EBDC's available but not captafol or folpet														
Dikar 80W		8	8	8	8	8	8	8	8	8	8	8	8	8
Polyram 80W		8	8	8	8	8	8	8	8	8	8	8	8	8
dinocap 25W				2	2	2	2	2	2	2	2			
Assumption 3 - captafol available but not EBDC's or folpet														
captafol (RSAT)		3(gal)												
thiram 65W					8	8	8	8	8	8	8	8	8	8
dinocap 25W					2	2	2	2	2	2	2			
captafol (RSAT)		3(gal)												
ferbam 76W 4/					8	8	8	8	8	8	8	8	8	8
dinocap 25W					2	2	2	2	2	2	2			

Assumption 4 - folpet available but not captafol and EBDC's

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folpet 50W	8	8	8	8	8	8	8	8	8	8	8	8	8
dinocap 25W			2	2	2	2	2	2	2	2			
thiram				4	4	4	4						
or													
ferbam 4/				3	3	3	3						

Table 6B.

Fungicides Applied	Total Number Sprays	Fungicide/Season No Pest Management	Fungicide/Season With Pest Management	Total Fungicide Costs 5/ No Pest Management	Total Fungicide Costs 5/ With Pest Management 1/	Relative Commercial Acceptibility Of Program 6/
captan 50W	13	104	83.4	$159.12	$127.60	
dinocap 25W 2/	8	16	12.8	40.64	32.51	Very Good
thiram 65W 3/	4	16	12.8	21.60	17.28	to
or	--			-------	-------	Excellent
	13		Total	$221.36	$177.39	
ferbam 76W 3,4/	4	12	9.6	15.00	12.00	
	--			-------	-------	
	13	Total without thiram		$214.76	$176.11	
Alternatives						
Assumption 1 - folpet, captafol, and EBDC's not available						
thiram 65W	14	112	NA	$151.20	-	None to
dinocap 25W	8	16	NA	40.64	-	Very Poor
	14		Total	$191.84		
ferbam 76W 4/	14	112	NA	$140.00	-	None to
dinocap 25W	8	16	NA	40.64	-	Very Poor
	--			-------		
	14		Total	$180.64		
Assumption 2 - EBDC's available but not captafol or folpet						
Dikar 80W	13	104	83.2	170.56	136.45	Good to
	--			-------	-------	Very Good
	13		Total	$170.56	$136.45	
Polyram 80W	13	104	83.2	166.40	133.12	Very Good
dinocap 25W	8	16	12.8	40.60	32.51	to
	--			-------	-------	Excellent
	13		Total	$207.00	$165.63	
Assumption 3 - captafol available but not EBDC's or folpet						
captafol(RSAT)	1	3	NA	$ 64.50	-	None to
thiram 65W	10	80	NA	108.00	-	Very Poor
dinocap 25W	7	14	NA	35.56	-	
	--			-------		
	11		Total	$208.06		
captafol(RSAT)	1	3	NA	$ 64.50	-	
ferbam 76W 4/	10	80	NA	100.00	-	None to

dinocap 25W	7	14	NA	35.56	-	Very Poor
	--			-------		
	11		Total	$200.06		

Assumption 4 - folpet available but not captafol and EBDC's

folpet 50W	13	104	83.4	$208.00	$166.80	
dinocap 25W	8	16	12.8	40.64	32.51	Good
thiram	4	16	12.8	21.60	17.28	to
or	--			-------	-------	Very Good
	13			$270.24	$216.59	
ferbam 4/	4	12	9.6	15.00	12.00	
	--			-------	-------	
	13	Total without thiram		$263.64	$211.31	

1/ ST = silver tip; GT = green tip; HIG = half-inch green; TC = tight cluster; P = pink; BL = bloom; PF = petal fall; and C = cover sprays.

2/ Dinocap (Karathane) used for powdery mildew control only.

3/ Thiram and ferbam used primarily for control of rust diseases.

4/ For processing varieties only.

5/ Prices per pound or gallon quoted by a large Michigan distributor on 5/2/80 as follows: captan - $1.53; dinocap - $2.54; ferbam = $1.25; thiram - $1.35; Dikar - $1.64; Polyram - $1.60; dichlone - $4.70; captafol - $21.50; and folpet - $2.00.

6/ Price not considered in acceptibility rating.

7/ The fungicides are applied as tank mixtures wherever possble.

8/ Applies to Southeast region only. Folpet is often phytotoxic if applied before the 4th cover spray in states north of the Southeast region.

9/ Assume sprays are applied concentrate rather than dilute. Further reductions may be possible with alternate middle system and extending intervals during dry weather.

Selected References

1. Albert, J. J., and F. H. Lewis. 1962. Effect of repeated applications of dodine and of captan on apple scab foliage lesions. Plant Dis. Rep. 46:163-167.

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DRUPES

I. Commodity Information

Drupe fruits, also called stone fruits, include cherries, peaches, prunes, plums, nectarines, and apricots. Almonds also are a member of these closely related plant species, but in popular usage they are considered separately because the seed of almonds is used for food, while for stone fruits the fleshy mesocarp is consumed. Production of drupes is an agricultural specialty because a great deal of knowledge and skill is required for profitable production of these crops.

However, trees of this group of fruits also are popular for small back yard orchards. With a minimum amount of care they will grow well, produce a modest amount of fruit, and serve as attractive ornamental plants because of their showy, fragrant flowers, and shiny, green foliage.

Tree fruits of this group do not grow in tropical or subtropical environments. They also do not thrive in severely cold climates. The climate of central and northern California and the southeastern United States (except central and southern Florida) is especially well suited to production of stone fruits. In northern states commercial production is concentrated in those areas where large lakes or sheltered river valleys exert a moderating climatic influence during winter. California has by far the largest acreage of stone fruits (Table 1), and sizable acreages are located in Michigan, New York, Pennsylvania, South Carolina, Virginia, Washington, and Oregon.

In moist climates stone fruits require frequent sprays of fungicides, largely for prevention of fruit decay and certain foliar diseases. Less frequent sprays may be applied in dry climates and in situations where the trees are grown in relative isolation from others that may be susceptible to the same diseases.

II. Diseases of Drupes Controlled by Captan

Captan is used to control several diseases of drupes which are very destructive and can be limiting factors in production of these crops. The importance of captan is illustrated in the widespread state recommendations of its use, summarized in Table 2.

Brown rot -- Brown rot is caused by two fungi, *Monilinia laxa* and *Monilinia fructicola*. Both of these are widespread in Pacific Coast regions. Although *M. laxa* has been reported in New York (10), Michigan (1), and Wisconsin (13), it is not widespread in the eastern and central states.

There are two destructive phases of brown rot. Blossom blight occurs during the spring months. Large numbers of blossoms may become infected during warm, moist weather conditions. These infections may result in significant crop losses due to destruction of blossoms, but more significantly, twigs on which the infected blossoms are found die after the fungus invades them from the diseased blossoms. The second phase is that of fruit decay, which is much more destructive than blossom blight. Immature fruits are comparatively resistant to brown rot during the early stages of their development, but they become very susceptible as they approach maturity. Infected fruits, whether mature

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or immature, are a total loss because a single infection destroys the entire fruit within 1 or 2 days. Further, a small percentage of infected fruits in a truckload often causes the entire load to be rejected in wholesale markets.

Brown rot can become extremely destructive during warm, moist weather conditions. A single infected fruit or blossom can produce millions of spores, which become airborne in the wind, especially when accompanied by rainfall. Each spore can produce a new infection which under ideal temperature and moisture conditions may result in a new crop of spores within 3 days. An epidemic of brown rot, therefore, can develop very rapidly, especially in commercial fruit orchards where susceptible crops are grown in large concentrations and cultivars ripen over a 3 to 6-month period even in the same orchard.

Chemical sprays are the only reliable means for control of brown rot in commercial orchards. There are no resistant cultivars, and effective biological control agents have not been found. Small orchardists and home gardeners sometimes can omit certain sprays if they are careful to remove and destroy all infected blossoms and fruits and other susceptible plants that may be growing nearby. This practice is not reliable in larger orchards or in crowded neighborhoods, however.

Chemical sprays for brown rot control are based on prevention - usually that of establishing a protective fungicide barrier between the fungus spore and susceptible plant tissues. Fungicides usually are ineffective for eradicating established infections of fungi that cause brown rot.

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Peach scab -- Scab is an important disease of peaches in the eastern United States, especially in the Southeast. Scab does not occur in the western states. It is caused by the fungus *Cladosporium carpophilum*, and is characterized by the formation of olive-green to brown spots on the surface of infected fruits and twigs. Leaves also may be infected, but leaf infections are of little economic importance. Scab is harmful to peach production in three ways: (a) its occurrence detracts from the appearance of peach fruits, making them unattractive to consumers, and therefore decreasing their value: (b) the lesions accelerate water loss from peach fruits, causing them to be smaller and have shorter shelf life; and (c) scab lesions are often invaded by the brown rot fungi, thereby hastening decay.

All peach cultivars are susceptible. Chemical sprays are essential for control. Captan is an important fungicide for control of this disease.

Cherry leaf spot -- Sweet and sour cherries are severely affected by the cherry leaf spot disease caused by the fungus *Coccomyces hiemalis*. This disease is especially important in northeastern and midwestern states. Fruit quality is affected by the severe defoliation of cherry trees that follows infection of cherry leaves by this fungus. Fruits from infected trees are small and low in the soluble solids which characterize good fruit quality. Cherry trees that are unprotected have reduced growth due to impared photosynthetic captacity, and they may become severely weakened and die from cold injury or other disease problems.

Bacterial spot -- Bacterial spot is a disease of nectarines, apricots, peaches, prunes, and plums which can become important on certain cultivars in the eastern United States. It is not important in other producing regions. The bacterium (Xanthomonas pruni) affects leaves, twigs, and fruit and causes severe defoliation as well as superficial spots on the fruit, which depresses quality. Infection does not affect eating quality, but infected fruits are unsightly and of little value in the marketplace. The disease also increases susceptibility to brown rot. Captan does not control bacterial spot, but it is used as a safener for dodine to prevent foliage injury from the latter (7). Captan's value, therefore, is to enable the use of dodine for control of bacterial spot.

Coryneum blight -- This disease is important in orchards of peaches, apricots, nectarines, and sweet cherries west of the Rocky Mountains, except that sweet cherries in California are not often affected. Its occurrence is rare in orchards of the eastern U.S. It is characterized by diseased spots on leaves, twigs, buds, and fruit. The fungus (Coryneum biejerinckii) is active during periods of moisture (winter and spring months) but is not active during the dry summer months. Twigs and buds are infected in the winter and spring, and leaves and fruit in the spring. The major effects are dieback of twigs, death of flower buds, and reduced quality of fruits due to surface lesions. Losses in volume may occur if infections cause significant twig die-back or bud kill, but losses in fruit quality are usually more important. Several sprays during the moist periods usually are sufficient to control the disease. Although captan is effective, ziram,

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Bordeaux mixture, or fixed copper sprays are more commonly used. Captan is of the most value during the relatively infrequent moist periods that may occur during spring and summer months, when certain other sprays would be injurious.

Anthracnose of peaches -- This disease is not widespread but is important in certain peach producing localities in the Carolinas. The fungus *Glomerella cingulata* which causes this disease attacks peach fruits just as they are maturing and causes a firm, conical decay that is often confused with brown rot. Infected fruits are useless for human consumption. The firmness of the decayed area and masses of pink spores on the fruit surface are diagnostic. The fungus has a wide host range and spreads to peaches from the natural wild hosts that are common in many orchards in the Carolinas. Captan sprays used to control scab and brown rot also control anthracnose. The disease usually becomes a problem only in orchards where sulfur or benomyl have been used to the exclusion of captan. Maneb or folpet also control anthracnose, but neither is labelled for use against this disease.

Russet scab of prunes -- Russet scab occurs on prunes in California. The roughened surface results in reduced quality of affected fruits. The cause of russet scab is unknown, but sprays of captan or dichlone at full bloom control the disease.

III. Uses of Captafol and Folpet on Drupes

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Folpet is an important fungicide for control of leaf spot on tart cherries, but is is injurious on sweet cherries. Captafol also is used for control of leaf spot on tart cherries that are harvested mechanically. These two fungicides are very effective for control of leaf spot, and they are important alternatives to captan. Dodine, which also can be used for leaf spot control as an alternative to captan, can be used only on tart cherries as an preharvest spray; it must be used postharvest on sweet cherries. Potential resistance in the target fungus threatens continued effectiveness of dodine for cherry leaf spot, and dodine does not control brown rot.

Captafol and folpet rarely are used for other diseases of drupes.

IV. Use Practices for Captan on Drupes

a. Mode and rates of application and volumes of water

Before low volume and ultra-low volume spray application equipment became commonplace, fruit trees were sprayed until the foliage became thoroughly wet. A so-called "dilute" spray required that spray be applied until it was at the point of running off of the foliage. In dilute sprays, 1 pound of captan (active) per 100 gallons of spray was the dosage usually specified for control of diseases of drupes. The amount of spray required for application to the point of run-off ranged from 100 to 500 gallons per acre, depending on the size of tree, stage of development, density of canopy, and number of fruits to be protected.

Current practices are to use approximately 1.5 to 4.0 pounds (active) of captan per application per acre, applied in 5 to 500

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gallons of water. Low volume and ultra-low volume applications require up to 20% less fungicides than dilute sprays - a saving which results from negligible run-off when low-volume sprays are used. Air-blast ground equipment is the most common mode of application. Aircraft application is used sometimes when rainy weather prevents the use of ground equipment in muddy fields. Most farmers apply captan, captafol, and folpet with their own spray equipment, but frequently aerial applications are made by custom sprayers.

Captan also is applied in small orchards by hand-held equipment such as power-driven handguns, back-pack sprayers, and hose-end applicators. Most of these require the use of "dilute" dosages. However, the amount of fungicide actually used varies widely according to the efficiency of the spray equipment and the skill, care, and knowledge of individual applying the sprays. The common notion that "more is better" may frequently result in excessive application of fungicide by those who are not skilled in the principles of pesticide application.

b. Formulations, frequency, and number of applications

Captan and folpet almost invariably are used as wettable powder formulations on stone fruits, while captafol is used primarily in a flowable suspension that mixes easily with water. The most common formulations contain 50% active ingredient for captan and folpet; while the captafol flowable suspension contains 4 pounds of captafol per gallon of formulation. Captan also is available as an 80% wettable powder.

Frequency and number of applications are extremely variable. Factors that influence the number of applications include the length of the period of susceptibility to disease; sensitivity of cultivars to injury (some cultivars of plums and prunes are injured by captan); weather conditions; rate of maturity; availability, cost and suitablilty of alternative fungicides; amount of disease pressure; and customary spray practices. In the last instance, these fungicides may sometimes be added as "insurance" against disease when insecticides are applied, even though a fungicide application may not be required.

c. Geographic areas of use

Large amounts of captan are used on peaches, plums and nectarines in the southeastern states. This use increased in the 1970's for two reasons. First, captan replaced wettable sulfur in many orchards as a control for scab of peaches and nectarines after it was learned that low soil pH adds to the problem of premature death of peach trees (18). Sulfur in its chemical reactions in the soil contributes significantly to soil acidity. Second, captan was added to sprays with benomyl for control of brown rot and scab after certain strains of the fungi responsible for these diseases were found to be resistant to benomyl (2, 8, 17, 20). Such mixtures have helped to limit the development and spread of these resistant strains (6).

In these states, captan may be used in as few as two sprays (preharvest sprays with benomyl for brown rot) to as many as ten or even more when used in bloom with benomyl for blossom blight, cover

sprays for scab control, and preharvest with benomyl for anthracnose and brown rot. Captan has good residual activity, and most sprays are applied at 2-week intervals in these orchards.

In other regions, captan use is less frequent though substantial. Scab and anthracnose are not common disease problems in California and the Pacific Northwest; therefore little captan (or other fungicide) is used for these diseases. Captan is not as effective as benomyl for brown rot in California, but state regulations require that benomyl be used with another fungicide and captan usually is the fungicide chosen. Usually, one spray of benomyl plus captan is applied during bloom and one 3 weeks before harvest. In some western states captan is important for control of Coryneum blight and cherry leaf spot. When Coryneum blight threatens during infrequent moist periods, captan is especially important because most other effective materials may be injurious when leaves and fruits are on the trees.

In Michigan, New York, Pennsylvania, and other northern states captan is used for control of brown rot, peach scab, and cherry leaf spot. Seven to 14-day intervals generally are used, depending on the stage of development. Fewer sprays per year are used in the northern states because scab of peaches is less severe than in the Southeast, and cherries mature relatively early.

Substantial amounts of captan are applied on stone fruits in very small orchards and in residential areas all over the United States. Captan is one of the most readily available fungicides. It is economical to use, and has a broad range of activity. It

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probably is the most widely used of all fungicides on fruit trees in small orchards less than 2 acres in size.

d. Average size of orchards

Orchard size is extremely variable. Commercial farms of several thousand acres of fruit trees are not uncommon, but most are much smaller - usually in the range of 50 to 500 acres. The growing popularity of "pick your own" fruit farms has increased the probabilities of success for small, well-managed commercial orchards. The success of family-operated small farms in recent years may signal a change in the long-term trend to larger fruit farms.

Many farmers who grow fruit trees also grow other crops. Cereal grains, soybeans, and other crops are rotated with fruit orchards. Others grow small fruits, vegetables, nuts, or other tree fruits in addition to stone fruit crops.

Also important are the small orchards grown in residential areas either for supplementary income or for home use. These orchards may be several acres in size, but more often they consist of only a few trees. Captan has several advantages for orchards of this type. First, captan has been considered to be relatively nontoxic and therefore safe to use as a general-purpose fungicide. Second, captan has broad-spectrum disease controlling activity and is effective for the most common diseases of fruit trees. Third, captan is readily available to the general public in container sizes that are appropriate for home use, and at a reasonable price.

e. Postharvest uses

Fruits that are sold in the fresh market often receive postharvest treatments to improve attractiveness and shelf-life. Such treatments usually include washing (or spraying) the fruits with cold water to remove debris, reduce respiration, and control decay; brushing the fruit to remove trichomes (fuzziness) of peaches; an often application of a fruit wax to reduce weight loss and improve appearance. Fungicides to control decay usually are applied during one or more of these operations. Until 1972, captan was one of the most widely used fungicides in postharvest treatments. Since 1972, benomyl has largely replaced captan in postharvest treatments because it is more effective for brown rot control. However, the spreading occurrence of benomyl-tolerant strains of the brown rot fungus may increase the need for captan as a postharvest treatment. Captan now has relatively minor use as a postharvest treatment; but it has significant importance as an alternative if other methods are not effective.

f. Number of acres treated

It is difficult to obtain very precise estimates of the acreage of stone fruits sprayed with captan each year. The number depends upon the price, availability and effectiveness of alternative spray materials, prevalence of diseases, and changing grower practices. Table 1 lists the estimated amounts of material used, approximate number of acres sprayed, and range of applications per acre. The amount consumed in homeowner use was excluded because reliable information is unavailable.

Most fungicide application is made by ground equipment. Aerial application is made when weather conditions are not acceptable for ground equipment to be used in the field.

V. Safety Practices

a. Extent of exposure during mixing, filling and spraying

The extent of personal exposure to captan during measurement of the fungicide, filling and mixing the spray tank, and applying the material is being studied at the Pennsylvania State University. Results are not yet available. However, a similar study there with mancozeb and benomyl (K. D. Hickey, unpublished data) showed that unprotected hands and forearms received a dermal exposure of 700.09 and 54.09 ug/hr, respectively, during weighing and filling operations for convential spraying, and 402.13 and 56.09 ug/hr when using low-volume equipment. During spraying, unprotected face, hands, neck, and forearms received dermal exposures of 5696.1 and 17,664.4 ug/hr benomyl and mancozeb, respectively, with convential spraying; and 3522.7 and 9262.2, respectively with low-volume sprays.

The lower rate of exposure to benomyl probably reflects the lower dosage rate required when benomyl is used. The data indicate that less exposure results from low-volume sprays than from conventional dilute or high-volume sprays, since less time is spent per acre measuring and weighing with low-volume sprays, and the actual exposure during application is less.

An airblast sprayer operating steadily at 2.5 mph would be capable of spraying 6 to 8 acres per hour. However, time must be allowed for refilling spray tanks and machine maintenance, so that a single spray unit rarely sprays more than 5 acres per hour even with low-volume sprays.

b. Protective clothing and equipment

The use of protective clothing to minimize exposure to captan, folpet, or captafol ranges from no protective measures at all to a complete unit which includes impermeable suits, boots, goggles, and respirator. The persons who are least likely to use protective clothing are those with only a few trees, for whom spraying means 5 to 10 minutes of work once every 2 weeks. Persons who are most completely protected are those who mix toxic insecticides with the fungicide in the spray tank. The primary aim of such protection is to protect against the insecticide; protection against captan, folpet, or captafol is incidental. Because some insecticide is usually mixed with these fungicides in commercial orchards, most workers in these orchards wear some type of protective clothing even though it may not be as complete or impermeable as is desirable.

c. Phytotoxicity

Captan generally is not injurious to plants, but there are some important exceptions. Captan is injurious to the foliage of certain cultivars of plums (Stanley prune is an important example) and may cause russeting of fruit surfaces in plums. When used as

routine sprays in peach and nectarine orchards captan sometimes causes injury when mixed with liquid formulations of phosphate insecticides. This problem can be avoided by using wettable powder formulations of phosphates, but sometimes mild leaf injury may occur even with wettable formulations of phosphates.

Sporadic postharvest injury of peaches, apricots, and nectarines has occurred following preharvest sprays of captan when the fruit receive postharvest treatments in packing houses (3). Such injury is characterized by surface discoloration of the fruits, and it may be severe enough to render the fruits unmarketable. Some cultivars are susceptible to injury, while others are not; and the problem also does not always appear whenever captan is used with susceptible cultivars.

Captafol and folpet also may be injurious with certain defined methods of use and environmental conditions. Usually, injury with these materials can be avoided with careful observance of rate and precautions listed on labels for proper use of these fungicides.

VI. Alternative Fungicides and Practice

The availability and suitability for use of various alternatives differ according to the several diseases. To simplify discussion, each disease will be considered separately. Impacts and alternatives are summarized in Tables 3 through 5.

a. Fruit decay and blossom blight

Captan is not effective for Rhizopus decay, and its absence

would affect control of this disease. Benomyl, thiophanate methyl, and triforine are superior to captan for control of brown rot. However, resistant strains of the brown rot fungus for benomyl and thiophanate methyl seriously limit their usefulness as substitutes for captan. Triforine, which was recently registered for use on peaches, can be used only for blossom blight under current label restrictions. Dichlone, sulfur, maneb, dicloran, line sulfur, and copper compounds sometimes may be used for control of brown rot, but all are either less effective than captan, have significant potential for plant injury, or both (e.g. 4,5,8, 15,21,22).

Several new fungicides now being tested, especially triforine, biloxazol, vinclozolin, and iprodione offer superior control of brown rot (e.g. 18,21,23). Registration of one or more of these would substantially reduce the need for captan.

Other practices, especially orchard sanitation and removal of wild hosts near fruit orchards, help to reduce the need for fungicides, but none can entirely eliminate the need for them.

b. Scab

Sulfur is an effective substitute for captan for control of peach scab, but it is less effective for scab on nectarines (16). Benomyl and thiophanate methyl are superior for scab control but resistant strains of the scab fungus limit the usefulness of these two fungicides. Sulfur has the disadvantage of increasing soil acidity problems, and its use near harvest results in less red color and sometimes roughened surface of fruits sold in the fresh

much sulfur is required for equivalent control for certain diseases. If captan use were discontinued, overall pesticide use is anticipated to increase slightly due to a greater use of sulfur as an alternative fungicide.

VIII. Summary of Impacts for Disease Control of Stone Fruits

The immediate impacts of registration cancellation of captan, folpet, and captafol would be severe for producers of sweet cherries, especially those in the Midwest and eastern regions. The immediate impacts for producers of other stone fruits would be less severe, but the long-term effects could be very damaging. Most sweet cherry growers would have to rely on less effective fungicides for leaf spot control. Dodine could be used to control leaf spot effectively, but brown rot problems would increase with dodine. Either alternative would lead to severe disease losses in seasons that are especially suitable for disease outbreaks in cherry orchards.

Cancellation of captan would lead to increased use of sulfur as a fungicide, but this change could lead to harmful effects on soil acidity problems; somewhat (10-20%) more frequent applications of fungicides with consequently larger imputs of labor, equipment, and fuel; and needs for more frequent applications of lime to the soil. Assuming that the current slow pace of development and new registrations of fungicides continues, fungicide tolerance problems would likely increase following greater reliance on benomyl, thiophanate methyl, and dodine for disease control on stone fruits. Also, the use of fungicide mixtures to delay

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market. Cancellation of captan would leave only sulfur for control of scab where benomyl- and thiophanate methyl-resistant strains of the fungus exist. There are no alternative methods for control of this disease.

c. Cherry leaf spot

State recommendations for control of cherry leaf spot include captan for sweet and tart cherries, captafol for mechanically harvested tart cherries, and folpet for tart cherries. Folpet is injurious on sweet cherries. There are altenative fungicides but most have disadvantages. Benomyl and thiophanate methyl are very effective for control, but both are prone to resistance problems. Resistance in Coccomyces hiemalis is already widespread in Michigan (9) and greater reliance on these two fungicides would increase the resistance problems. Dodine is effective, but it is not used for sweet cherries because it is not effective for brown rot control.

Dichlone, ferbam, and ziram may be used in some areas in the West, but these are considered to be less effective in the eastern United States. Fixed copper is very effective but is risky from the standpoint of phytotoxicity and may not be used on sweet cherries. Glyodin and sulfur have some activity against this fungus but are not very effective (11,12).

Cancelled registration of captan for use on sweet cherries would have a serious impact in the eastern United States. Captafol is not registered for use on sweet cherries, folpet is phytotoxic, and dodine does not control brown rot. Benomyl and thiophanate methyl could be used in orchards where resistance has not yet

developed, but past experience indicates that resistance would become prevalent within a few years. Assuming that no new, effective fungicides are registered before this resistance problem becomes widespread, ferbam, dichlone, or ziram would soon become the fungicides of choice, and they would be used now in orchards where resistance problems exist.

The impact of captan cancellation would be less severe for tart cherries. Dodine or folpet can be used as effective replacements for cherry leaf spot and captafol can be used for mechanically harvested fruit. Benomyl or thiophanate methyl may be used in orchards that have no resistance problems.

d. Bacterial spot

No chemical treatment is highly effective for control of bacterial spot in all orchard situations. The best control is afforded by use of resistant cultivars and attention to soil factors that may damage root systems (such as nematodes or poor soil drainage), which lead to increased susceptibility of the disease. The absence of captan would not seriously jeopardize control programs for bacterial spot, but would increase reliance on oxytetracycline for control of the disease on susceptible cultivars.

e. Anthracnose of peaches

Maneb is the only useful alternative to captan for control of peach anthracnose, but maneb is not registered for control of anthracnose. In South Carolina piedmont regions, where this

disease sometimes is severe, infections might be reduced or eliminated by orchard cultivations to remove weed hosts of the fungus. Cultivation of sloping land would add severely to erosion problems, however, and would not be a desirable approach to control.

f. Coryneum blight

Captan is applied as needed for control of Coryneum blight of stone fruits in many western states. There are certain effective compounds that can be used at certain stages of growth instead of captan (fixed coppers, ziram, and dichlone are important alternatives in fall or early season sprays), but these are injurious when used during summer months. Maneb can be used during the summer, but it is less effective than captan. In some western states, during unusual rainy periods, Coryneum blight might become severe without captan sprays. Control methods other than fungicide sprays are not effective.

VII. Integrated Pest Management and Comparative Use Practices

Captan is important in current and planned integrated pest management (IPM) practices for certain peach diseases. Examples of such uses include the following:

a. Control of fungicide tolerance

No cases of fungicide tolerance to captan have ever been reported for diseases of stone fruits, even though its use has been widespread since its introduction in the 1950's. Resistant

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Coryne - blight

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the following:

[illegible]

strains of fungi have developed for certain other fungicides, notably benomyl and thiophanate methyl, in recent years. In the 1974-1976 period benomyl tolerance in the brown rot fungus was observed in Michigan (8), New York (17), Australia (20), and South Carolina (R. W. Miller, Unpublished), and later California (J. M. Ogawa, Unpublished), and in the peach scab fungus in Georgia (2), and South Carolina. Captan mixed with benomyl was used in many locations to combat further development and spread of the tolerant brown rot fungus, while in Georgia sulfur was mixed with benomyl to control the tolerant peach scab fungus. The value of this practice was demonstrated in research (Zehr, unpublished, and Jones, unpublished) which showed that development of benomyl-tolerant strains of the brown rot fungus was slowed in orchards where mixtures were used. Also, in South Carolina only one location of benomyl tolerance was found since 1976, and in this location benomyl was used exclusively. These and other results (6) indicate that captan is a valuable tool to decrease the development and spread of strains of fungi that are resistant to certain other fungicides.

b. Control of Coryneum blight

Captan is a valuable fungicide for control of Coryneum blight during rainy periods. Captan is essential in these management practices.

c. Development of IPM programs for peach scab

Recent research (14) shows that the minimum number of spray

applications required for control of peach scab depends in part upon the kind of fungicide used. If sulfur is used, one more application of sulfur would be required than if captan were used. Sulfur also has the disadvantage of contributing to soil acidity, thereby adding to peach tree short life problems, and requiring more frequent applications of lime. If benomyl or thiophanate methyl are substituted for captan, one less application is required in a minimum spray schedule, but tolerance problems would require that sulfur be added in a mixture. A minimum application schedule involving captan and alternatives could be developed to retain the advantages of captan while reducing the number of applications from current levels.

d. Control of peach anthracnose

Captan is used to control scab in orchards where anthracnose is known to occur. Nonchemical methods of control, which would be necessary if captan were no longer available, would add to erosion problems and be harmful to long-term peach production.

e. Comparison of rates of materials

The preceding discussion dealt with various alternative chemicals. Most of these, e.g. benomyl, dodine, dichlone, triforine, and thiophanate methyl require only one-fourth to one-half as much active material per acre as is required for captan. Some other compounds, notably sulfur and fixed copper or Bordeaux mixture, require more active material. Sulfur may also cause skin irritation for those harvesting ripened fruit. Up to six times as

the predominance of such strains in commercial fruit would be less likely to succeed without the use of captan.

Integrated pest management programs would be hindered by the loss of captan. Strategically applied sprays of captan as related to weather conditions and stage of plant development are very important for minimum fungicide applications for control of Coryneum blight, peach scab, and anthracnose. Attempts to control tolerant strains through judicious use of fungicide mixtures also would be impared.

The total impact of registration cancellation depends to a large degree upon regulation and availability of other fungicides. Will zineb and maneb continue to be available for disease control? Will registration of benomyl and thiophanate methyl continue? Progress in registration of certain experimental fungicides that are efficacious for stone fruit diseases would soften the blow to fruit growers. However, these new materials will be much more expensive than captan, folpet, or captafol because of the very high costs of developing new pesticides.

The impact in small fruit orchards would likely be substantial. Captan is the most widely used fungicide available to small fruit growers. Benomyl and certain other fungicides could help to fill the void, but costs would be considerably higher.

Table 1. Acreage, rates of application and amounts of captan, folpet, and captafol used on peaches and cherries by geographic regions of the United States in 1978.

	Number of Acres Treated	Number Treatments	Rate a.i. Per A.	Total Used (lb)	Total /A
NORTHEAST					
Peaches:					
Captan	16,061	5.2	2.1	178,446	11.1
Captafol	229	1.1	2.9	720	3.1
Folpet	16	1.0	1.3	21	1.3
Cherries:					
Captan	4,133	3.0	2.4	29,912	7.2
Captafol	29	1.0	0.6	17	0.6
Folpet	896	3.9	1.7	6,075	6.8
SOUTHEAST					
Peaches:					
Captan	34,969	3.9	1.6	222,108	6.4
Captafol	0	-	-	-	-
Folpet	47	1.0	0.4	21	0.4
Cherries:					
Captan	-	-	-	-	-
Captafol	-	-	-	-	-
Folpet	-	-	-	-	-
NORTH CENTRAL					
Peaches:					
Captan	8.060	3.9	1.4	43,309	5.4
Captafol	0	0.0	0.0	0	0.0
Folpet	6	5.0	0.85	41	3.85
Cherries:					
Captan	6,842	1.7	1.9	22,532	3.3
Captafol	12,308	3.6	1.6	69,713	5.7
Folpet	152	1.8	1.2	340	2.2
WEST					

Peaches:

Captan
Captafol
Folpet

Cherries:

Captan
Captafol
Folpet

Table 2. State-by-state listings of fungicides for control of brown rot, scab, cherry leaf spot, and Coryneum blight of drupe fruits based on 1978-1979 disease control recommendations.

	Chemicals listed for control of:			
State	Brown rot	Scab	Cherry Leaf spot	Coryneum Blight
Alabama	benomyl captan sulfur	benomyl captan sulfur	--- 1/	--- 1/
Alaska	---	---	---	---
Arizona	---	---	---	---
Arkansas	benomyl captan sulfur	benomyl captan sulfur	---	---
California	benomyl captan sulfur dicloran maneb Bordeaux mixture 2/ dichlone 2/ fixed copper 2/ captafol 3/	---	---	captan ziram
Colorado	---	---	---	captan dichlone zineb maneb fixed copper
Connecticut	sulfur dichlone captan benomyl dicloran	sulfur captan thiram benomyl	---	---
Delaware	sulfur captan benomyl dichlone 2/	sulfur captan benomyl	---	---
Florida	sulfur	sulfur	---	---

--	benomyl captan	benomyl captan		
Georgia	benomyl captan sulfur dicloran	captan sulfur	---	---
Hawaii	---	---	---	---
Idaho	benomyl captan dodine ferbam ziram sulfur	---	captan dodine ferbam dichlone ziram	---
Illinois	---	---	---	---
Indiana	---	---	---	---
Iowa	---	---	---	---
Kansas	captan sulfur benomyl dicloran	captan sulfur benomyl	---	---
Kentucky	captan sulfur benomyl	captan sulfur benomyl	---	---
Louisiana	benomyl captan	benomyl captan	---	---
Maine	---	---	---	---
Maryland	benomyl captan dichlone 2/ dicloran	captan sulfur	---	---
Massachusetts	dichlone 2/ sulfur captan benomyl	sulfur captan thiram benomyl		
Michigan	benomyl captan dichlone 2/ sulfur lime sulfur 2/	sulfur captan	captafol 4/ captan dodine 4/ benomyl sulfur 5/	---

--			ferbam 5/	
Minnesota	captan ferbam	---	---	---
Mississippi	benomyl captan	unavailable	---	---
Missouri	captan benomyl	benomyl	---	---
Montana	lime sulfur 2/ polysulfide 2/ benomyl captan dichlone 2/ sulfur	---	benomyl captan glyodin dodine	---
Nebraska	captan benomyl	---	captan ferbam benomyl	---
Nevada	---	---	---	---
New Hampshire	---	---	---	---
New Jersey	benomyl captan sulfur dichlone 2/	benomyl sulfur captan	captan benomyl glyodin	---
New Mexico	benomyl captan dicloran	---	---	---
New York	benomyl dichlone 2/ captan sulfur ferbam dicloran thiram	benomyl captan thiram	benomyl captafol 4/ dodine ferbam glyodin fixed copper 4/ folpet	---
North Carolina	sulfur captan benomyl	sulfur captan benomyl	---	---
North Dakota	benomyl captan sulfur	---	benomyl captan	---
Ohio	sulfur	---	captan	---

--	captan thiram benomyl		benomyl ferbam	
Oklahoma	benomyl captan sulfur	captan sulfur	dodine captan benomyl folpet	---
Oregon	benomyl captan dodine ferbam sulfur ziram	---	captan dodine ferbam dichlone ziram	Bordeaux mix. fixed copper{ sulfur captan ziram
Pennsylvania	benomyl captan dichlone 2/	benomyl sulfur captan	ferbam 5/ benomyl captan captafol 4/	---
Rhode Island	captan folpet	---	---	---
South Carolina	benomyl captan sulfur	benomyl captan sulfur	---	---
South Dakota	---	---	---	---
Tennessee	captan benomyl sulfur	captan benomyl sulfur	---	---
Texas	benomyl captan sulfur	benomyl captan sulfur	---	---
Utah	---	---	---	---
Vermont	captan	---	captan	---
Virginia	captan sulfur benomyl	captan sulfur benomyl	benomyl folpet captan ferbam	---
Washington	sulfur dichlone 2/ captan	---	---	captan dichlone maneb fixed copper

West Virginia --	benomyl captan sulfur	benomyl captan sulfur	captan folpet{ benomyl	---
Wisconsin	benomyl captan ferbam sulfur	---	captafol dodine benomyl	---
Wyoming	---	---	---	---

1/ Dash indicates that the disease and/or crop on which it occurs is not economically important in the state indicated.

2/ Not listed for preharvest use.

3/ Prunes only.

4/ Tart cherries only.

5/ Sweet cherries only.

Table 3. Estimated impacts of registration cancellation for captan on peaches, nectarines, and apricots.

Disease	Effective Substitutes	Some Less Effective Substitutes	Cancellation Effect
Brown rot	benomyl, thiophanate methyl, triforine	sulfur, dichlone, dicloran, maneb lime sulfur, copper compounds, ferbam, calcium polysulfide, zineb	Increased fungicide resistance problems will lead to less effective control in 2-5 years. Triforine may be used only for blossom blight of peaches.
Scab	sulfur, benomyl, thiophanate methyl	none	Increased soil acidity problems following greater reliance on sulfur. Thiophanate methyl or benomyl use leads to resistance problems.
Bacterial spot*	oxytetracycline	neutral zinc	negligible
Anthracnose	none registered	none	Severe effects in some orchards might be overcome by using maneb with benomyl for brown rot control
Coryneum blight	fixed coppers, dichlone, ziram	zineb, maneb, dichlone, sulfur, ferbam	Moderate to severe losses in some states may develop during rainy summer weather because effective substitutes may not be used on trees in full foliage.
Cherry leaf spot sweet cherries	benomyl, thiophanate methyl, dodine	ferbam, ziram, dichlone, glyodin, sulfur	Severe. Resistance to benomyl and thiophanate methyl already is widespread in some areas. Dodine does not control brown rot. Less effective substitutes would be used.

Table 4. Estimated impacts of registration cancellation for captan use on cherries.

Disease	Effective Substitutes	Some Less Effective Substitutes	Cancellation Effect
Cherry leaf spot tart cherries	benomyl, thiophanate methyl, dodine, folpet, captafol (on mechanically harvested fruit)	ferbam, ziram, dichlone, glyodin, sulfur	Mild unless folpet and captafol use also is cancelled. Resistance to benomyl and thiophanate methyl is widespread.
Brown rot	benomyl, thiophanate methyl	sulfur, maneb	Increased fungicide resistance problems will lead to less effective control in 2-5 years.
Coryneum blight sweet cherries	fixed coppers, dichlone	zineb, ziram maneb	Moderate to severe losses may develop during rainy summer weather because effective substitutes may not be used on trees in full foliage.

Table 5. Estimated impacts of registration cancellation for captan on plums and prunes.

Disease	Effective Substitutes	Some Less Effective Substitutes	Cancellation Effect
Brown rot	benomyl thiophanate methyl	copper compounds, ferbam, sulfur, zineb, dichlone, calcium polysulfide	Increased fungicide resistance problems will lead to less effective control in 2-5 years.

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BERRY FRUITS AND GRAPES

I. Commodity Information

Berry fruits and grapes are important crop plants in the United States. Total production value from grapes exceeds that of any single other deciduous fruit. It amounts to more than the combined production value of apples and pears, and is almost double that of all stone fruits (USDA, Agricultural Statistics 1979). The fruit from the grapevine is a true berry and for this reason grapes are generally treated along with other berry crops or small fruits in pomological studies. In England grapes and small fruits are collectively referred to as soft fruits, a term that aptly describes the nature of the fruit from these plants. With softness, perishability associated with rot diseases is a factor of considerable importance.

Berry crops have been associated with man since prehistoric times. Wild berries were important foods in ancient diets and they were gathered by primitive peoples long before written records were kept. Even today, a volume of wild berries is gathered and processed commercially. The value of the wild blueberry crop, which is harvested mainly in New England, exceeded $15,000,000 in 1974 (Census of Agriculture, U.S. Department of Commerce, 1974).

Domestication of soft fruits started in prehistoric times and is still under way. Grapes were one of the first fruit crops cultivated. In contrast, other soft fruits have a short history of cultivation and some are still being hybridized with wild germplasm. Wild selections have been incorporated into some of the newest strawberry cultivars released from the strawberry breeding program at Davis, California. The blueberry was uncultivated until the early 1900's. The first blueberry cultivars were selections from wild plants in New Jersey made at the beginning of the present century. Even in grapes, wild species from the southeastern United States are important in breeding programs, particularly as rootstocks or as sources of disease resistance.

The principal soft fruits are grapes, strawberries, brambles, cranberries, blueberries, and gooseberries (currants). These are derived from wild species of the genera, _Vitis_, _Fragaria_, _Rubus_, _Vaccinium_, and _Ribes_. Botanically these genera belong in four separate plant families. Other than the fact that each genus produces soft fruit types, they have little in common. Excepting grapes and gooseberries, most soft fruit cultivars have originated in North America. This is important in the disease picture in such crops because diseases were able to move into plantations from wild sources during the selection process. This, in turn, means that disease was a selection pressure during domestication, and as a consequence disease resistance has been selected wittingly or unconsciously in many soft fruit cultivars, especially in areas where wild relatives of the crop still exist.

European grape types, which are important in production of grapes in California, were derived from *V. vinifera* in the Old World. When first brought to eastern North America, these types failed completely. They were extremely sensitive to diseases and pests, such as Pierce's disease, black rot, downy mildew, powdery mildew, and phylloxera, which are endemic in the eastern United States. Wild selections from the native bunch grape types and muscadines, and hybrids between *V. vinifera* and the American species, gradually permitted a grape industry with cultivars tolerant to the American grape diseases to develop in eastern states. The grape industry could not expand into the giant that it now is, however, until European type grapes were planted in California, where disease pressure is less, in the middle of the last century.

Each soft fruit crop has an array of fungus disease problems. Fungi causing root and wood rots and obligate parasites generally do not respond to fungicidal treatments. They are controllable only by altering the environment, by changing the cultural practices, or by host plant resistance. In contrast, fungus pathogens causing fruit rots or foliage diseases can usually be controlled or partially controlled by fungicides. Botrytis fruit rot, caused by *Botrytis cinerea*, is a disease common to several soft fruits. Captan is a major fungicide used for controlling this disease, and it is a valuable fungicide for controlling certain foliage diseases as well.

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The amount of captan used in soft fruit disease control programs will be a function of the acreage planted and the targeted fungi for each crop. It will be influenced by the relative value of the control achieved, balanced against the cost of application. Soft fruits are high-value crops and growers will use captan even if the control is not complete if it more than offsets the cost of application.

The relative values and production of each soft fruit crop are given in Table 1 for the year 1978. The five million plus tons of soft fruits harvested in the United States in 1978 amounts to approximately 19% of the total fruit produced that year. Grapes accounted for 89.9% of the soft fruit production and strawberries for 6.4% of the remainder. Grapes and strawberries are obviously the major components of soft fruit production.

The distribution of grape, strawberry, and minor soft fruit acreage and production is given in Tables 2, 3, and 4. The combined production of grape and strawberries in California amounts to 84.2% of the total soft fruit production in the United States. As far as total captan usage for small fruits is concerned, the major component is captan used for disease control on grapes and strawberries in California. Other usage will be discussed below.

II. Use of Captan for Controlling Diseases of Grapes

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For Controlling Mildew of Grapes

Three somewhat different fungus disease patterns occur on grapes in the United States. These correspond to different climates and consequently different disease pressures. The western states, California, Washington, and Arizona, grow 643,000 acres of European-type grapes. The disease picture is similar in all three states because the cultivars are similar and in the grape producing areas the rainfall pattern is the same. These areas in all three states would be deserts or near-deserts if irrigation were not available during the major part of the growing season. In the West, rains rarely occur during the growing cycle and conditions are almost ideal for grape cultivation.

The Great Lakes Region, comprised of New York, Pennsylvania, Michigan and Ohio grows 75,000 acres of American bunch grapes and European-American hybrids. The region has cold winters and rainy summers. European-type grapes generally fail partly due to the cold winters and partly due to diseases, which are favored by the high humidity and frequent wetting of foliage associated with summer rains.

The South and Southeast, with small grape production in Arkansas, Missouri, North and South Carolina, and adjacent states, has wet, humid summers similar to the Great Lakes states. In addition many of the vineyard sites are in endemic areas of Pierce's disease and European as well as most bunch grape cultivars do not survive longer than four or five years. This limits grape production to muscadines and tolerant bunch grape types. Rains and the warm humid conditions of summer in these states favor the occurrence of fungi causing fruit rots and foliage blights.

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In all regions vines are planted in rows and trained to stakes or trellises. No grapes in American vineyards are permitted to trail on the ground nor to grow free into trees as is practiced in parts of the Old World and South America. The trellises vary within and between growing areas (Weaver 1976). They function to facilitate management of the vines and harvesting the crops. They also assist in disease control, permitting vines to be easily treated with fungicides. Also the trellis opens the vine canopy to air circulation and thereby makes conditions less favorable for fungus infection and disease development. Pruning and training systems also aim to open the vine to air circulation.

Weeds are controlled in all vineyard areas. In the West they are eliminated by cultivation or through application of herbicides in order to conserve water. In the East they may also be eliminated or mowed. In addition to saving water, weed control makes harvesting easier. It also permits better fungicide application and it reduces the humidity within the vine canopy by providing cross ventilation.

In the West, vineyards are irrigated by various methods. RAinfall is usualy insuffcent to establish young vines or to maintain mature ones. Under such conditions water and fertilizer management can be adjusted to favor fruit production and to cut down on excessive vine growth. This helps in disease control.

In spite of the most favorable cultural conditions and the best vine management fungus diseases occur in all grape regions. Differences in climate produce a difference in fungus infection patterns. In the West the principal fungus diseases are Botrytis fruit and storage rot or bunch rot, Phomopsis core and leaf spot, and raisin molds. In the Northeast they are black rot, downy mildew, and Botrytis rot. In the South they are the same as in the Northeast plus anthracnose, bitter rot, and ripe rot.

Botrytis cinerea is omnipresent on dead tissues and old fruit mummies throughout all grape regions. It infects berries through the stigma at flowering time (McClellan and Hewitt 1973). In the berry it remains latent until near harvest when it resumes growth and produces rot. It can also infect berries directly in late season, especially when rains occur before harvest. White cultivars are generally more sensitive to it than red ones are. Captan does not control Diplodia associated with bunch rots (Hewitt 1974).

Phomopsis cane and leaf spot is caused by *Phomopsis viticola*. This disease is part of a complex that was formerly called grape dead arm. The wound canker that produces the 'dead arms' is caused by a separate fungus, *Eutypa armeniacae*, which does not respond to captan treatments (Moller *et al*. 1979). It causes leaf and stem spotting. It is of minor importance most years. In years of severe infection it can cause shoot breakage and poor shoot growth, making pruning more difficult and increasing pruning costs. It can also cause fruit rots at harvest or in storage. It occurs in both eastern and western United States.

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Raisin molds are caused by several saprophytic fungi including Botrytis that infect berries that are damaged by unseasonable rains during the drying cycle. Although captan is registered for use on raisins that are damaged by rain, neither it nor any other registered fungicide will prevent rot damage (Kasamatis and Lynn 1975). Damage in excess of $100,000,000 occurred to the California raisin crops in both 1976 and 1978.

Downy mildew and black rot are caused by the fungi, *Plasmopara viticola* and *Guignardia bidwellii* respectively. Downy mildew is common in the Northeast and black rot is common throughout the entire East. Captan is one of the most effective fungicides against downy mildew and it is moderately effective against black rot (Burr *et al*. 1980). Both fungi infect grape foliage and fruits starting just prior to bloom and secondary infections can occur through the remainder of the growing season. All vinifera cultivars and Catawba, Chancellor, DeChaunzc, Delaware, Fredonia, Lugs, Missouri Riesling, Niagara, and Rougeon are extremely sensitive to downy mildew. Vinifera cultivars and Aurora, Catawba, Concord, Dutchess, and Niagara are very sensitive to black rot.

Anthracnose, bitter rot, and ripe rot are caused by the fungi *Elsinoe ampelina*, *Melanconium fuligineum*, and *Glomerella cingulata* respectively. These are leaf, cane, and fruit spotting fungi that infect certain bunch grape cultivars in eastern United States, appearing about midseason in vineyards that have not been sprayed to control black rot. Bitter rot causes a fruit rot in muscadine grapes, but muscadines are resistant to most of the fungus diseases of eastern United States (McGrew 1972).

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Registered uses for captan or grapes fall into three patterns. These are early spring sprays for control of Phomopsis cane and leaf spot, cover sprays in the West for control of Botrytis bunch and storage rot, and cover sprays in the East for control of downy mildew, black rot, and various fruit rots.

In California captan is applied to grapes for Phomopsis cane and leafspot control in early spring. Captan applications are approximately as effective as dormant treatments of vines with dinoseb or sodium arsenite. Their timing, however, is more critical than that required for the dormant treatments. For this reason captan is less widely used than dormant sprays. Captan has an advantage that it is less toxic to humans than the dormant materials. Captan is sprayed twice at a rate of 1.5 to 3 lbs a.i./acre shortly after bud break and again when shoots are about six inches long.

Only the cultivars Thompson Seedless, Tokay, and Grenacke are treated; othe cultivars are resistant to the fungus. The disease does not cause serious crop loss, but, if a high incidence of shoot infection occurs, pruning costs may increase, causing some economic loss. No more than 0.8% of California grapes are treated. This amounts to about 4,900 acres (Sall _et al_. 1980 and Sall 1980).

Captan is applied by ground sprayers, usually by the grower or his employee but occasionally by a pest control operator. For captan application, California pesticide regulations require that the spray rig operator wears boots, coveralls, a face shield or goggles, gloves, and a waterproof hat. Applications are made when no other field operations are being carried on. ONly the operator or an occasional spectator

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Applications of fungicide are needed only if 1.44 inches total rain falls during February and March. In the northern San Joaquin Valley where the disease is frequently a problem, the critical rainfall probability is usually greater than 50% and routine treatment is justified. In the southern San Joaquin Valley, however, routine treatments are not justified. In such areas where conditions favoring infection are rare, significant benefit can be achieved by waiting for rainfall predictions before applying captan (Sall et al. 1980).

In the Northeast, captan treatments are also applied for Phompsis cane and leaf spot control. Two sprays are routinely used. However, since the disease that was called dead arm has been demonstrated to be a complex of Phomopsis cane and leaf spot with Eutypa dieback, there is some question for the need to control Phomopsis. The disease is seldom severe and fruit rots associated with it are rarely seen (Pierson 1980).

Alternative chemicals registered for grape use against Phomopsis cane and leaf spot are dinoseb, sodium arsenite, and mancozeb. All four chemicals are equally effective. Dormant treatments with dinoseb and sodium arsenite are preferred by many growers because there is greater leeway for timing treatments.

Botrytis fruit and storage rot or bunch rot affects wine and table grapes throughout California and wine grapes in Washington state. In California, 49% of wine grapes (152,240 acres) are treated one or more times with captan or benomyl/captan and at least half of the table grapes (30,000 acres) are so treated (Sall and Schick 1980). The value of the treated acres is at least $300,000,000 at 1980 prices.

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Management practices can reduce bunch rot infection and damage but they do not control the disease. If the disease is not controlled, table grapes rot in transit or in storage and wine grapes rot before harvest or they are rejected at the winery.

Botrytis infection occurs at bloom time and the fungus remains latent in the developing berry until near harvest. It may become active again at that time and spread to adjoining berries in the fruit cluster. It also spreads directly to healthy berries if rains occur before harvest (Sall and Herschfelt 1980). Without control, the disease could cause a 7% ($21,000,000) loss (Sall 1980). Sprays applied at bloom time and captan dusts near harvest will reduce bunch rot by at least 20% and possibly by as much as 69% (Sall 1980). White wine grapes, especially Chenin blanc, White Riesling, Chardonnay, and Sauvignon blanc, are more sensitive than most red grapes. However, the red cultivar Zinfaudel rots badly also (Sall and Hirschfelt 1980). Cabernet Sauvignon is generally tolerant unless harvest is delayed until fall rains begin. Thompson Seedless and Emperor are more tolerant than other table grapes. Early-harvested table grapes shipped to fresh fruit markets are rarely affected.

Captan or benomyl/captan sprays are applied 3 to 6 times to table grapes and 2 to 4 times to wine grapes. Captan is used at 1-2 lbs. a.i./acre. Total acreage treated is estimated at 182,240 (Sall 1980). Sprays are generally applied in the first and second application put on at bloom time but dusts containing 4-5 lbs a.i./acre captan may be substituted for later applications in mid-summer up to harvest. Captan 50W or 10D are common formulations used. Sprays are applied with ground

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rigs but dusts are applied both by plane and ground dusters. The farmer or his employees make most applications; pest control operations apply less than 25% of the application. Applications follow California pesticide safety regulations for captan. Usually only two people are involved in the spraying or dusting, the tractor driver and the mixer. Applications are scheduled, often at night, so they do not interfere with workers engaged in other field activities.

If rain threatens before harvest, applications of a captan dust up to three days before the rain starts may reduce Botrytis rot as much as 69 - 80% (Sall 1980). Careful attention to weather forecasts thus aids control of this disease. Cultural practices can reduce the need for treatment but captan at bloom time or just prior to rain is essential for effective control of bunch rot.

Alternative chemicals registered for use on grapes against Botrytis rot are benomyl, dichloran, and maneb (at bloomtime). Benomyl treatment is generally more effective than captan but benomyl-resistant strains have been isolated in California (Sall 1980). Consequently benomyl is used with captan at full strength. Economic factors along with benomyl-resistance in Botrytis will probably bring about greater dependence on captan in the future.

Black rot is the major fungus disease problem with grapes in eastern United States. It is most effectively controlled by ferbam sprays although captan is moderately effective against it. Downy mildew is also as frequent a problem in eastern vineyards and captan is effective against it. For control captan sprays containing 1.5 to 2 lbs a.i./acre are applied by ground sprayers. In New York 35% of the grape

plantings (15,000 acres) are sprayed 4 or 5 times with captan (Pierson 1980). Captan has special state registrations in the Southeast for use against anthracnose, bitter rot, and ripe rot. The amount of captan used for this purpose is small.

Captan is also registered in many states for home garden use on grapes. The amount used for this purpose is unknown.

Registered alternatives to captan for downy mildew in New York are folpet, fired copper and lime, and ferbam. The coppers can cause phytotoxicity. Ferbam is less effective than captan against downy mildew.

III. Captan Use for Controlling Strawberry Diseases (from A. O. Paulus, University of California, Riverside, California).

"Botrytis fruit rot, commonly known as gray mold rot, is the major fruit rot of California strawberries. It is caused by the fungus, Botryis cinerea, which thrives in wet conditions and cool temperatures. Botrytis spores are produced in tremendous quantities and are carried by wind. Without fungicide sprays applied as protectants, growers can experience losses of 100% during periods of high disease potential."

"Fungicides currently registered and fairly effective for control of Botrytis fruit rot include captan, thiram (Thylate) or combination of benomyl with either captan or thiram. Fungicides must be applied to strawberries as a protectant since it is impossible at this time to ascertain when severe fruit rot conditions will prevail in any given area of strawberry production in California (this is true in other states also). In southern California with a shorter fruiting season

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approximately 9-12 fungicide sprays are applied per season. During periods of high disease incidence applications must be made as often as every three days. In northern California with a larger fruiting season as many as 20 applications of fungicide could be applied."

"Captan, thiram, or benomyl are not highly effective for the control of Botrytis fruit rot but are the best registered materials available to California growers. Captan is favored by many strawberry growers because of a waiting period after application of 0 days for captan and 3 days for thiram. During heavy strawberry production in California it is sometimes necessary to pick berries as often as every 2 or 3 days. Under these conditions it is impossible to use thiram because of the 3 day waiting period."

"A captan-benomyl combination treatment increased yield of strawberries 3.07 tons per acre during March and April, 1977 experiments at the University of California, South Coast Field Station when compared to no treatment. Captan alone increased yields of 2.53 tons while thiram alone increased yields 2.18 tons per acre."

"Captan is an essential fungicide for the California strawberry industry and drastic economic loss would occur to growers if unavailable for use in California." (A. O. Paulus 1980).

Data from the 1979 "Pesticide Use Report" published by the California Department of Food and Agriculture list a use of 41,159 lbs a.i. captan used on strawberries in California. This is probably a minimal figure because captan does not require a permit for its use nor does it need to be reported.

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If captan is used on strawberry acreage outside of California at the same rate that it is used on the 13,700 acres in California, the 22,600 acres outside of California would use an additional 67,800 lbs of captan (a.i.) for Botrytis rot. A small additional amount might be used for leaf spot registrations in other states and an untold quantity might be used on strawberries in home gardens.

IV. Captan Use on Minor Small Fruit Crops

Captan is registered for use against spur blight and anthracnose, and Botrytis fruit rot on bramble crops. These are minor uses but important to growers of these fruits.

It is also registered for use against Botrytis fruit rot and mummy berry of blueberries in Washington and Oregon and against the same blueberry diseases plus anthracnose in New Jersey. These again are important uses to growers but small as far as quantities of captan used are concerned. Captan has brought order out of chaos for the blueberry industry as it is the only fungicide effective in controlling Botrytis rot and anthracnose close to harvest time, particularly in wet weather. Captan is also often used in place of captafol for Phomopsis canker control. This is done where growers have developed allergies to captafol.

Studies have shown on two widely separated farms in New Jersey (Walt Adams Farm, Burlington County and Blueberry Acres in Ocean County) that blueberry production was cut by 75% without regular applications of captan and that the fruit which was harvested was of inferior quality. If captan registration were to be cancelled growers would be forced to

[illegible] be effective [illegible]

[illegible] that it is used on the [illegible] in California. The

[illegible] outside of California would use an additional [illegible]

For Botrytis rot, [illegible] a total amount might be

[illegible] spot registrations in other states and [illegible]

[illegible] on strawberries in some gardens.

Use on Minor Small Fruit Crops

[illegible] is registered for [illegible]

[illegible] fruit [illegible]

[illegible] growers of these fruits.

[illegible] also registered for use against Botrytis [illegible]

blueberries in Washington and Oregon [illegible]

[illegible] es plus anthracnose in New Jersey. [illegible]

[illegible] uses to growers [illegible]

[illegible] Captan has brought [illegible] for the blueberry

[illegible] as it is the only fungicide [illegible] in control [illegible]

[illegible] anthracnose close to harvest time, [illegible]

[illegible] also often used in [illegible]

[illegible] is done where growers have developed [illegible]

[illegible] on two widely separated farms [illegible]

[illegible] County and blueberry farms [illegible]

[illegible] cut [illegible]

[illegible] [illegible]

[illegible] controlled growers would be

use other fungicides that are available and approved, but far more dangerous and costly (Sheridan, 1981).

It is also registered as a late season fungicide to use against certain fruit rots and twig blights of cranberries but this is a secondary use. Other fungicides are more effective.

Finally it is registered as a prebloom spray to control leaf blight of gooseberries (currants). The total use for this purpose might be 140 lbs.

Table 1. Value and production of grape and small fruit crops in the United States in 1978 (USDA, Agricultural Statistics 1979)

	Value	Production	
Crop	1,000 dollars	1,000 tons	%
Grapes	1,005,794	4,567	89.9
Strawberries	200,533	324	6.4
Cranberries	52,903	123	2.4
Blueberries	48,892	39	0.8
Brambles	31,192	26	0.5
Gooseberries (currants)	93	<1	<0.1
Total	1,339,407	5,079	

Table 2.-- Commercial grape production in the United States in 1978 (from 1974 and 1978 Census of Agriculture, U.S. Department of Commerce. Acreage figures marked with an asterisk all from the 1974 Census)

Major producing States	Acreage	Percentage of total Production
California	616,597	88.0
New York	43,018	4.1
Washington	21,941	4.1
Michigan	15,761*	1.5
Pennsylvania	12,359	1.3
Ohio	4,181	0.3
Arizona	4,116*	0.3
Arkansas	2,809*	0.2
North Carolina	1,999*	0.2
Missouri	1,339*	0.1

Table 3.- Commercial strawberry production in the United States (from Agricultural Statistics 1979, U.S. Department of Agriculture)

Major producing States	Acreage	Percentage of total Production
California	13,700	79.7
Oregon	5,000	5.3
Florida	2,000	4.5
Washington	3,300	2.7
Michigan	2,700	2.4
Ohio	1,500	1.3
New York	1,300	1.0
Louisiana	800	0.8
Arkansas	900	0.7
Wisconsin	1,400	0.6
New Jersey	700	0.5
North Carolina	2,100	0.5
Pennsylvania	900	0.4

Table 4. Commercial production of minor soft fruits in the United States in 1978 (from Agricultural Statistics 1979, U.S. Department of Agriculture)

Crop	Major producing state	Acreage	Production in tons
Cranberry		23,160	122,952
	Massachusetts	11,200	59,000
	Wisconsin	7,000	41,100
	New Jersey	3,000	11,150
	Washington	1,100	6,950
	Oregon	860	4,725
Blueberry		35,250	26,452
	Maine	14,800	9,050
	Michigan	8,000	7,250
	New Jersey	7,800	5,445
	North Carolina	3,400	2,012
	Washington	800	1,945
	Oregon	450	750
Brambles		10,250	3,653
	Oregon	7,320	2,446
	Washington	2,930	1,207
Gooseberry (Currant)			
	Washington	140	108

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PAPAYA

I. Commodity Information

Papaya, *Carica papaya* L., is grown in all counties of Hawaii and is adapted for production between 32 degrees north and south of the equator. Commercial production in the United States is restricted to Hawaii (USDA, 1978). In 1979, 1840 acres were harvested while the 1980 estimate is 1580 acres due to a 20 percent tree loss from wind damage and *Phytophthora* during 1979. Over 1000 acres are non-producing at this time. Production for 1979 was 5,843,000 pounds with a total income of $9,289,000; almost 30 percent of this was sold locally (Papaya Briefs, 1979). The average farm size is 24.8 acres. The largest 5 farms control 68 percent of the total acreage, and the largest farm (1100 acres) controls 50 percent of total acreage.

The following is a list of practices involved in the production of payaya:

Practices	Method	Man hours/acre per year	per 3-year crop
Layout, digging holes, seeding or planting in field	hand		18
Fertilization/3 year life of crop			72
Year 1		34	
Year 2		24	
Year 3		14	
Weed control			56
Year 1	hand (24) chemical (8)	32	
Year 2	chemical	12	
Year 3	chemical	12	
Pest control (disease & insect)			148
Year 1	spray with ground rig	44	
Year 2	"	54	
Year 3	"	50	
Pre-plant fungicide drench	soil drench		18
Harvesting			290
Year 1		0	
Year 2		154	
Year 3		136	
Sorting and packing			60
Year 1		0	
Year 2		40	
Year 3		20	

(Michael Muench, 1980)

II. Pest Information

Captan is used for control of damping-off and root-rot diseases. The pathogens are Phytophthora palmivora and Pythium species. These fungi are found in all papaya-producing regions and persist in the soil, where they attack the roots and stems. Disease is favored by heavy rains and poor drainage. Phytophthora is also important in causing fruit rots which can occur any time during warm, wet periods.

During 1979, 20 percent of the trees were lost from Phytophthora root rot (this was the highest loss recorded over the last 30 years) (Aragaki, et al., 1980; Alvarez, 1980).

Soil types in Kauai, Maui, and Oahu permit the use of captan; but captan cannot be used in the county of Hawaii due to its volcanic rock soils (Alvarez, 1980; Ko, 1980). About 280 acres are treated only in the county of Maui (Nary, 1980).

III. Captan Use

Captan 50 wettable powder is the formulation registered for use on papaya. Captan 50W is available in 4 pound bags and is sold for $0.92 per pound a.i. (Ortho, 1980). It may be applied as a pre-plant or post-plant treatment. However, pre-plant applications are not used commercially. For pre-plant, apply 1 pound a.i. in 50 to 100 gallons water per 200 foot row; with 20-200 foot rows per acre, such an application results in 20 pound a.i. per acre. For post-plant, apply 1/4 pound a.i. in 50 to 100 gallons water per 200 foot row; this results in 5 pound a.i. per acre. Both pre-plant and post-plant

is used for control of [illegible]

are [illegible]. These

found in all papaya-[illegible]

attack the roots and stems. [illegible]

[illegible]

which can occur any time during the [illegible]

ng 1979, 20 percent of the trees were [illegible]

(this was the highest [illegible]

al., 1980; [illegible]

In Kauai, Maui, [illegible]

be used in the [illegible]

, 1980; [illegible]

of Maui [illegible].

[illegible] usually product is the formulation registered for use in

50W is available in 4 pound [illegible]

[illegible]. It may be applied as a [illegible]

eatment. However, [illegible] applications are [illegible]

[illegible] apply 1 pound a.i. in 50 to 100 gallons

rows with 20-200 foot rows per acre, [illegible]

[illegible]

[illegible]

applications are applied directly to the soil (Hawaii Dept. Ag., 1978). All applications of captan are ground applied, and are applied by the grower (Alvarez, 1980). Captan is used once pre-plant and once post-plant within 3 months of establishing plantings (Hawaii Dept. Ag., 1978).

Post-pesticide treatment activities consist of the following: Dithane M-45, Bravo 6F, Bravo 500, Copper-sulfate, and wettable sulfur are applied by spray rig.

Operation	When performed
Thinning	From one month to six weeks after seed germination. A second thinning occurs at four months and a final thinning occurs six months after seeding.
Fertilization at planting: osmocote	No application during the first month, then at monthly intervals from the second to 34th month.
Weed control	As needed.
Fruit harvest	Begins one year after planting of seeds.

rely on the soil [illegible]

m of weeds are [illegible] applied, and are applied by the

, 1980). [illegible] is used [illegible] pre-plant and [illegible]

within 3 months of [illegible] planting [illegible]

[illegible] treatment activities [illegible] of the

and No 5, Bravo [illegible], Benlate [illegible], and

are applied by spray rig

when performed

Three [illegible] to six weeks after [illegible]

emergence. A second [illegible]

at four months and a final [illegible]

[illegible] months after planting

No application during the [illegible]

then at monthly intervals [illegible]

Exposure to humans in the field is during thinning operations and again at 3 to 5 months after planting during fertilization.

The other pesticide registered for use on papaya is captafol, but it is not used commercially. However, it is recommended that captafol registration be retained because it should control Phytophthora better than captan, and also has longer residual activity.

Experiments indicate that use of virgin soil in a seed bed prevents damping-off in the volcanic soils in Hawaii County (Ko, 1980).

IV. Summary

The commercial papaya crop production is restricted to the State of Hawaii. During 1979, 20 percent of the trees were lost from root rot disease, indicating the importance of the disease. Captan use for damping-off and root disease is essential to establishment of an orchard except in the County of Hawaii. The method of application and timing results in limited exposure to workers.

Data gaps:

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TARO

I. Commodity Information

Taro, Colocasia esculenta (L.) Schott, is grown in Hawaii, California, Florida, Louisiana, Puerto Rico, Guam, and American Samoa. The crop is grown under wetland (paddy) and dryland culture. The majority of the wetland taro grown in Hawaii is made into "poi" (Vieth, etal 1980). Lehua Maoli, a well-adapted and high-yielding taro, is the predominate wetland cultivar in Hawaii. Dryland taros, which include all cultivars of taro (C. esculenta) and dasheen or araimo (C. esculenta var. globulifera (Engl. and Krause) Young) are grown in Hawaii and other parts of the United States.

The 450 acres grown in Hawaii comprise 90% of total U.S. taro acreage (USDA, 1979). Ninety-five percent of the Hawaiian crop is under wetland cultivation (Vieth etal, 1980). County distributions are: Kauai - 210 A (47%), Hawaii - 110 A (24%), Maui-Molokai-Oahu - 130 A (29%) (Hawaii Agr. Rept. Su. 1979). The crop is grown on 132 farms. The 1978 crop in Hawaii consisted of 7.68 million pounds valued at 1.03 million dollars (USDA, 1979). Cultural practices involved in producing taro include:

Disease control	Chemicals applied as sprays or wettable powder
Insect control	Chemical
Weed control	Cultivation, chemical
Fertilization	Broadcast or side-dress
Irrigation	Flooding (wetland), furrow, sprinkler, or

-- drip (dryland)

Harvest Leaves and corms removed by hand

II. Pest Information

Captan is registered for use on taro. Captan is used to control Pythium soft rot caused by *Pythium carolinianum* (Ooka and Yamamoto, 1979) *P. aphanidermatum*, and *P. splendens* (Trujillo 1967). It is used only for wetland taro and only in Hawaii (Ortho, 1979). *Pythium* attacks corms or young plants under wet, warm conditions and during the flooding stage of growth. *Pythium carolinianum* is not in the soil but in the taro sets, irrigation water, and reservoir hosts. The organism builds up with time on leaf trimmings (left over from harvesting of leaves for laulaus) and other plant debris left in the fields. *Pythium aphanidermatum* and *P. splendens* are found in soil. These pathogens also build up on plant debris left in the fields. Pythium soft rot occurs sporadically and the average loss is estimated at 20%. When losses exceed 50% fields may be abandoned (Ooka, 1980).

III. Captan Use

The only registered captan product is Chevron's Orthocide 50W (Ortho, 1979). Five hundred pounds a.i. were used in 1980. About 10 acres are treated in Hawaii (10 A in Kauai) (Nary, 1980). Orthocide 50W is available in 4-pound bags at a resale price of $1.84 per pound formulated product (Ortho, 1980).

Captan is applied with a knapsack sprayer with a single nozzle at 50 lb a.i./acre in 500 gal water as a slurry to the soil surface prior to planting; this is tilled into a depth of 6 inches. Another means of application is to apply 50 lb a.i. with fertilizer as a homogenous dry mix; this mix is broadcast on dry soil before taro is planted and the field is flooded. Only one preplant application is made (Ortho, 1979). Efficacy data is available from Obrero, 1968.

Post-pesticide treatment activities include: immediate rotovation to incorporate captan into the soil (accomplished by one person), planting of seed taro in the field (about 3 days after captan application), flooding of the field (Ooka, 1980).

No other chemical is registered for use in control of Pythium soft rot in wetland taro (Ooka, 1980). Captan cannot be used if taro leaves are to be used as animal feed or human food (food would be luau or lau lau) (Ortho, 1979; Ooka, 1980).

IV. Summary

Taro, Colocasia esculenta, is grown primarily in the state of Hawaii under paddy or wetland cultivation for processing. Leaves are used occasionally in cooking. Captan is used for control of Pythium corm decay. Losses to this disease are significant but the use of this chemical is limited, with no other chemical or biological control recommended. Improvement could be made on the application method of captan to provide less exposure to the applicator.

Data gaps

led with a fungicide/ sprayer with a single nozzle at [illegible] in 500 ml water as [illegible] the [illegible]

this is filled into a depth of 5 inches. Another [illegible] of [illegible] to apply 50 lb a.i. with [illegible]

is broadcast on [illegible] soil before seed is planted [illegible] [illegible]. Only one preplant application is made [illegible], 1977)

is available from [illegible], 1983.

[illegible]ticide treatment of vitros includes [illegible] captan into the soil [illegible] by one percent.

of seed [illegible] in the field about [illegible] days after [illegible] flooding of the field [illegible], 1980).

chemical is registered for use in [illegible] of Pythium [illegible] taro (Ocka, 1980). Captan must be used if taro is [illegible] used as animal feed or human food [illegible] [illegible], 1979; Coke, 1980).

Colocasia is esculenta, is grown primarily in the [illegible] of [illegible] paddy or wetland cultivation for processing. Leaves are [illegible]ally in cooking. Captan is used for control of [illegible] [illegible]. Losses [illegible] this [illegible] are significant but the use of this [illegible], with no other chemical or biological control [illegible] could be made on the application methods [illegible]

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PINEAPPLE

I. Commodity Information

Pineapple, <u>Ananas comosus</u>, is grown mainly in Hawaii, with some produced in Puerto Rico (around 1%) and Florida (non-commercial plantings). Pineapple grows best close to the equator (about 25 degrees north or south of it). Optimum temperatures range between 70 and 90 degrees F (Roberts, J.O., 1977). The main variety planted is Smooth Cayenne (Roberts, 1977). The pineapple industry produced 675,000 tons of fruit (fresh weight) in 1978, resulting in a value of 63 million dollars (Hawaii Ag. Reporting Service, 1979). Processed value was 205 million dollars (85% processed, 15% fresh). There are 16 farms in Hawaii that produce pineapple; in 1978 they had 44,000 acres of pineapple (acreage is steady). The distribution is as follows:

Oahu		11,000 acres
Maui:	Lanai	16,000
	Molokai	4,000
	Maui	10,000
Other countries		3,000 (Ha. Ag. Report. Serv., 1979)

The following list describes the cultural practices involved in producing pineapples (list from Pineapple Growers Association of Hawaii, 1971):

Disease control	- dips at planting time; spray with ground rig.
Planting	- plant slips (part of stem below fruit) or crowns (part from top of fruit) by hand. (Planting cycle

-- is once every three crops.)

Insect control - spray with ground rig; soil injections (lindane); aircraft-applied baits for ants (mirex).

Irrigation - sprinkler and drip systems. Plants require 8-10" water; apply less water depending on rainfall.

Weed control - spray with ground rig; tillage.

Flower induction - spray with ground rig.

Fertilization - spray with ground rig; drip irrigation system.

Mulching - ground rig.

Harvesting - by hand.

Stripping - thinning of shoots done by hand.

Seed plant collection
- crowns collected at harvest, slips collected after harvest. Both done by hand.

Tillage - preplant.

II. Pest Information

Heart rot of pineapple is caused by Phytophthora parasitica, and heart rot and root rot caused by Phytophthora cinnamomi. Both pathogens are soil-borne and may be spread through propagating material. The inoculum is zoospores of the Phytophthora species (Rohrbach, 1980). The estimated infested area is 22,700 acres (Chevron, 1980).

III. Use of pesticide in producing commodity

Captan products are registered for use on pineapple (Ortho, 1979). In Hawaii captan is used as a dip treatment of sets before planting (Rohrbach, 1980). If captan were not available a 5 percent crop loss would result under optimum disease conditions.

Captan is used in all pineapple-producing areas of Hawaii and in 1976 5692 pounds a.i. of captan were purchased to treat 2800 acres. In 1979, 4,560 pounds of active ingredients of captan were used to treat 2,280 acres (Chevron, 1980). Registered captan products for pineapple are Chevron's Orthocide 50 wettable (Ortho, 1979) and Stauffer's Captan 50-WP (Stauffer, 1979). In Hawaii, captan is mostly sold in 4 pound bags; prices range from $0.92 per pound a.i. for 4 pound bags to $0.87 per pound a.i. for 50 pound bags (Ortho, 1980).

Captan dip treatments consist of 2 pounds of a.i. in 100 gallons of water. The dip machine requires two workers to treat 20,000 to 25,000 plants in 5 minutes, the number of plants required per acre.

IV. Evaluation of exposure and hazard

For dip treatments of planting stock, no obvious hazards are associated with captan based on use. The first crop is harvested about 2 years after the last application of captan and the second crop is harvested 3 years after the last application of captan.

V. Role of Captan

[illegible] (Smith, 1979).

[illegible] is used as a dip treatment [illegible]

1980). If captan were not available [illegible]

[illegible] under optimum climatic conditions.

[illegible] is used in all [illegible]

[illegible] a.i. [illegible] captan [illegible]

[illegible] pounds of active [illegible]

[illegible] (Sherrod, 1980). [illegible]

[illegible] Orthocide [illegible] (Lowe, 1979) [illegible]

[illegible], 1979). In Hawaii, [illegible]

[illegible] ranges from [illegible] per pound a.i. [illegible]

[illegible] for 50 pound bags (Brown, 1980).

[illegible] dip treatments consist of 2 pounds of [illegible]

The dip machine requires [illegible]

[illegible] in 5 minutes. [illegible]

[illegible] of exposure and hazard

[illegible] of planting stock, [illegible]

[illegible] captan based on use. [illegible]

[illegible] application of captan [illegible]

[illegible] after the last application of captan.

Effective control of <u>Phytophthora</u> heart rot and root rot is being obtained with captan.

VI. Alternatives

Alternatives registered for use in seed-piece (sets) dip treatment are fenaminosulf (Dexon 70W) and Mancozeb (Dithane M-45); however, neither chemical is currently used (Rohrbach, 1980). Mancozeb is an RPAR candidate. Captafol is the only other alternative chemical being used and is also an RPAR candidate.

Other control measures involve better drainage conditions through use of raised beds and sub-soiling, but these methods do not provide adequate disease control.

VII. Summary

Ninety-nine percent of the U.S. pineapple crop is grown in the state of Hawaii. The only effective disease control chemical used for heart rot and root rot (caused by <u>Phytophthora</u> <u>parasitica</u> and <u>P</u>. <u>cinnamoni</u>) are captan dip treatments for planting stock. Without the use of this chemical, crop losses are estimated at about 5 percent. Judging from time of application and methods of application, the exposure time is limited and should provide no hazards to the workers.

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CITRUS

I. Commodity Information

Citrus production in the United States is estimated at 1.15 million acres; annual production is over 264 million boxes valued at over 963 million dollars (USDA, 1978). Almost 70 percent of the crop is grown in Florida (766,100 acres), with the balance in California (265,700 acres), Arizona (52,700 acres) and Texas (68,000 acres) (Citrus Summary, 1980). The crop includes oranges, grapefruit, lemons, limes, tangelos, and tangerines. The crop is sold for processing and fresh market.

II. Pest Information

Captan is registered for use on citrus to control scab, melanose, and brown rot. Captan use, however, is very limited.

Scab, caused by *Elsinoe fawcetti*, is a fungal disease of economic importance on several citrus species including lemons, grapefruit, murcott oranges, and especially temple oranges. Valencia and sweet oranges are not susceptible to the disease. Certain rootstocks such as sour orange and rough lemon can become infected. The life cycle of the disease begins with attack of the blossoms and later the fruit. On fresh market fruit, blemishes lower the quality of the product and infected fruits can decay during postharvest storage. The disease is difficult to control when bloom commences early and extends over a long period. Inoculum comes from scab lesions on leaves, stems, and fruit on the tree. Spores are dispersed primarily by water-splashing action and

infection occurs only on young tissues. Leaves are most susceptible as they emerge from the bud and become immune by the time they have reached about 1/4 of their final width. The fruit of grapefruit become resistant after reaching a diameter of 6 cm and temple fruit after 3 cm (end of June).

Captan is not the most effective fungicide for the control of this disease; however, a single application of captafol over other fungicides including captan and folpet has been related to the persistence of captafol residues. The alternative for captafol was benomyl but resistant strains to benomyl have developed after five years of two applications per year. Copper fungicides are no longer recommended because of poor disease control. Captan, however, would be an alternative to other control measures such as benomyl copper.

Phytophthora brown rot on fruit is caused by *Phytophthora citrophthora* and *P. hibernalis* and is a problem primarily in California. Captan has been used as a control chemical on mandarines (10,000 acres in California) in the San Joaquin and San Bernardino area on less than 100 acres. In these regions copper cannot be used because the presence of copper and smog result in fruit spotting. Captan (2 pounds per 100 gallon rate) is applied only once as a pre-rainy season skirt (lower branches) spray in October-November. Air blast or boom sprayers put on the spray, applying 300-500 gallons per acre. One person per rig is needed to spray the trees and no special precautions are taken. Eight acres can be applied in 1 hour. Post-application operations include herbicide application, irrigation, and harvesting (starts late November, proceeds into May) (2). In Florida, Phytophthora fruit rot is limited

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and captan or copper is applied if necessary after rains. A maximum of 1,000 acres would be treated (6).

Melanose, caused by <u>Phomopsis citri</u>, causes cosmetic damage to fresh market fruit such as temple, murcott, oranges, lemons, grapefruit, and tangelos. Captan and captafol are registered for melanose disease control on citrus crops. Captafol is used over captan. Captafol at 1 qt. per 100 gallons spray is registered for application postbloom in Florida; some risk of phytotoxicity exists either immediately or later when oil or copper is applied. Captafol applied at this time suppresses mites and controls melanose. The alternative is copper used at the rate of 0.6 to 0.8 pounds of fixed copper in 100 gallons of spray. This treatment controls melanose without risk of phytotoxicity even when applied in late April or early May.

Scab and melanose diseases are not a problem in Arizona. These diseases are present in Texas, and copper is used for control of all of them (Trimmer, 1980). Captan is not used in Arizona (Troutman, 1980) and Texas (Trimmer, 1980).

III. Summary

Captafol is the only effective fungicide currently registered to control scab in Florida. Copper provides poor control and resistant strains have developed to benomyl. Captafol is limited for scab control on fresh market fruit (which comprises less than 20 percent of the acreage in Florida). Spray applications are made when fruit for fresh market harvest are not on the tree or at times before fruit set; thus the last captafol applications are made 6 to 9 months before fruit

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[illegible], caused by [illegible], causes [illegible] fruit such as berries, broccoli, cabbage, lettuce, grapefruit, [illegible]. Captan and captafol are registered for [illegible] diseases [illegible] crops. [illegible] [illegible] gallons spray is registered for [illegible] [illegible] of phytotoxicity exists either immediately or [illegible] copper is applied. Captafol applied [illegible] controls melanose. The [illegible] 0.8 pounds of fixed copper [illegible] controls melanose without [illegible] of phytotoxicity [illegible] late April or early May.

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harvest.

Captan is used to control Phytophthora fruit rot on fresh market fruit of manderin type in California. The treatment is better than copper only in terms of avoiding cosmetic damage (4).

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6. Whiteside, J. O. 1980. Personal interview by telephone.

-- ALMONDS

I. Commodity Information

Almonds, Prunum amygdalus Batsch., are grown exclusively in California with about 30% grown in the Sacramento Valley and 70% in the San Joaquin Valley. Less than 500 acres are grown in Southern California. The diseases for which captan is used are related to rainfall and temperature during critical stages of cultivar susceptibility. The average rainfall in southern San Joaquin Valley is 6.3 inches and in northern Sacramento Valley as high as 38.7 inches (Wilson and Ogawa, 1979, pp. 182).

According to figures for 1978, the major bearing acreages are in: (1) the Sacramento Valley - Yolo (12,117 A), Colusa (14,056 A), and Butte (30,155 A), and (2) the San Joaquin Valley - San Joaquin (29,658 A), Stanislaus (37,802 A), Merced (40,614 A), Madera (17,293 A), Fresno (21,159 A), Tulare (7,878 A), and Kern (53,997 A). The total bearing acreage for this season is 303,592 A and nonbearing 42,203 A (Ca. Crop and Livestock Report. Ser., June 1979). In a 1979 report the bearing acreage has increased to 322,602 acres (tentative; nonbearing not available). In addition to this, many new plantings have been made over the past several years: 1976 - 10,200 A; 1977 - 7,400 A; 1978 - 7,900 A (Almond Board of Calif., July 1979). There are 6,500 to 7,000 individual growers with the average farm size about 40 acres. The range in farm size is from one to 8,500 acres.

Cultivars and percentages based on crop yield are: Nonpariel (58.3%), Mission (15.2%), Merced (8.5%), Ne Plus Ultra (5.3%), Thompson (2.8%), Peerless (1.4%), and others (8.5%) (Almond Board of Ca., April 1980).

In 1978, California produced 181 million pounds of almond meats; with a season average price-per-pound of $1.40, the total value equaled 253.4 million dollars (USDA, 1979). The 1979 crop was much larger with 375.8 million pounds of meats (Almond Board of Ca., April 1980).

Cultural practices for almonds in the Sacramento and San Joaquin valleys are similar with the need for the following:

Disease control	- sprays by ground rig and aircraft
Insect control	- sprays by ground rig and aircraft
Irrigation	- flooding, sprinklers, drip, furrow
Frost control	- irrigation, wind machine, orchard heater
Weed control	- flailing, burning, strip and solid spraying, discing
Pollination	- introduction and removal of bee hives
Fertilization	- ground application & nutrient sprays; sprinkling systems
Harvest	- mechanical
Pruning	- by hand

(Reed and Horel, 1975; Meith et al., 1977).

II. Pest Information

Brown rot-- Brown rot on almonds is caused by two species of _Monilinia_. _M. laxa_ is responsible for blossom blight and some hull rot, while _M. fructicola_ is involved in hull rot and infrequent incidences of blossom blight (Wilson and Ogawa, 1979, pp. 65 and 66). _M.. laxa_ is more common. Disease is serious if not controlled in northern San Joaquin Valley and Sacramento Valley, while in areas south of Fresno County (including Kern County) disease incidence has been minimal (Ogawa, 1980. Personal information). _M. laxa_ overwinters on blighted blossoms, twigs, and mummies. Blossoms are susceptible to infection from pink bud to petal fall; hulls are susceptible as they split for 1 to 2 week periods from the middle of July. Serious _M. fructicola_ blossom blight was observed (in a commercial orchard) only during 1979; it was also identified in a 1977 test plot in Fresno County. Crop losses also result from reduction in fruiting wood in subsequent years (Wilson and Ogawa, 1979. p. 65).

Shot hole -- Shot hole is caused by _Coryneum beijerinckii_ and is widespread in both Sacramento and San Joaquin valleys. It is more common in areas with greater rainfall during foliation in February, March, and April (Ogawa, 1980. Personal information). _C. beijerinckii_ attacks leaves, blossoms, and fruit. Infection of leaves causes defoliation; blossom infection can cause blight (Wilson and Ogawa, 1980. p. 73).

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Leaf blight -- Leaf blight, caused by *Hendersonia rubi*, is common in Sacramento Valley and incidences have been reported as far south as Merced County (Ogawa, 1980. Personal information). *H. rubi* overwinters in blighted leaf petioles and infects petioles of new leaves. Petiole infections continue to move into buds, killing both leaf and flower buds during winter months (Wilson and Ogawa, 1979. p. 100).

Scab -- Scab, caused by *Cladosporium carpophilum*, is important only in northern Sacramento Valley and especially in Butte County (Wilson and Ogawa, 1979. p. 113). *C. carpophilum* infection of leaves causes greater defoliation than that caused by *Coryneum*. The scab fungus overwinters on twigs and infects leaves in the presence of free moisture (Wilson and Ogawa, 1979. p. 114).

The following are estimated crop losses for 1963 and expected losses after 5 to 10 years without fungicides.

		Without any 2/ fungicides for 5 to 10 years	
	1963 1/	Range	Average
Brown rot blossom blight	0.05 %	0-40%	20 %
Shot hole	2.0 %	0-50%	10 %
Leaf blight	0.1 %	0-20%	no data
Scab	0.05%	0-10%	no data

1/ Ogawa, J. M., et al. 1963
2/ Personal communication from growers and farm advisors.

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p. 173).

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and [illegible], 1979. [illegible]

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[illegible] years

	1983 1/	Range	Average
Blossom blight	0.0 [illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	0.1 [illegible]	[illegible]	[illegible]
	0.[illegible]	[illegible]	[illegible]

Captan is used in all almond production areas with more used in the Sacramento Valley than in the San Joaquin Valley. Following are estimates of acreage treated:

	Acres treated 1/	Captan treated 2/
Brown rot blossom blight	90-95%	80%
Shot hole	90-95%	5%
Leaf blight	5%	1%
Scab	10%	1%

1/ 1980 estimates by farm advisors and growers
2/ Percentage of total acres

III. Pesticide Use on Commodity

The 50W formulations of captan are the only ones used; this includes Orthocide 50 Wettable (Chevron product) and Captan 50-WP (Stauffer product) (Disease Control Guidelines for Almonds, 1980). All of the following products are registered for use on almonds: Orthocide 5 dust, Orthocide 7.5 dust, Orthocide 10 dust (ref. Ortho, 1979); Orthocide 15 dust (Ortho, 1980); Orthocide 50 Wettable, Orthocide 80 Wettable, Orthocide 4 Flowable (Ortho, 1979); Captan 50-WP (Stauffer, 1979).

Captan is applied during the following crop stages: for brown rot blossom blight at popcorn and bloom; for shot hole at popcorn, petal fall, and 5 weeks after petal fall; for leaf blight at petal fall and 5 weeks after petal fall; for scab at petal fall and 5 weeks after petal fall (Ortho, 1979; Disease control guidelines for almonds, 1980). The number of sprays applied would vary from season to season. First spray is for brown rot blossom blight at pink bud followed by a second at near full bloom if needed. Third spray would be for shot hole at petal fall. Cover sprays until 5 weeks after petal fall would be for shot hole, leaf blight, and scab. Sprays are not usually applied thereafter unless unseasonal rains enhance shot hole development or sprinkler irrigation warrants incorporation of fungicide for shot hole control (personal communication from growers and farm advisors, 1980). Until trees start to bear during the 4th leaf, trees normally are not sprayed with fungicides unless trees are sprinkler irrigated, then ziram and sometimes captan is sprayed.

Label use rates for captan products are as follows:

Orthocide 5 Dust:	50 lb/acre	(Ortho, 1979)
Orthocide 7.5 Dust:	45 lb/acre	(Ortho, 1979)
Orthocide 10 Dust :	40-50 lb/acre	(Ortho, 1979)
Orthocide 15 Dust:	40 lb/acre	(Byrne, 1980)
Orthocide 50 Wettable:	2 lb/100 gal	(Ortho, 1979)
Orthocide 80 Wettable:	1-1/4 lb/100 gal	(Ortho, 1979)
Orthocide 4 Flowable:	1 to 1-1/2 qt/100 gal	(Ortho, 1979)
Captan 50-WP:	2 to 3 lb/100 gal	(Stauffer, 1979)

Captan is sold in 4, 10, and 50 lb bags. Prices for captan 50 wettable are:

Price per lb active ingredient 1/

1	2	3	
$0.87	$0.77	$0.79	- - - - - 4 lb bag
$0.78	$0.77	$0.79	- - - - -10 lb bag

1/ Three retailers

Captan is applied by ground airblast sprayers, fixed wing aircraft, and helicopters (Kilgore et al., 1964). Ground airblast sprayers are usually used except when rains during bloom prevent the use of ground equipment (as in 1980). Both fixed wing and helicopter aircraft are widely used. Around 70-80% of the growers own airblast equipment while custom applicators own aircraft. The total number of licensed agricultural pest control operators registered to make aerial applications in specific almond-producing counties are: Butte 8, Kern 41, Merced 35, Stanislaus 21, San Joaquin 32, and Yolo 4, of which about half are home based. The maximum number actually involved in captan application on almonds could be one-fourth but usually much less of the total.

Airblast spray tanks have an average capacity of 500 gallons with the tank constructed of stainless steel (25%) or epoxy-coated steel (75%). Half of the airblast sprayers apply semi-concentrate sprays using 50-100 gal per acre. Dilute applications are made using 300-400 gal per acre. Dilute applications are made using 300-400 gal per acre. The centrifugal pumps used produce about 100 psi. Spray droplets from nozzles are further broken up by the airblast traveling around 100 mph at the outlet. Volume of air produced ranges from 30,000 to over 100,000 cfm based on units. The chemical is directly placed in the sprayer after approximately 1/3 of the tank is filled with water. Tractors used to pull airblast sprayers have both closed (20%) and open (80%) cabs. They travel between 2 to 3 mph and are used during periods of no wind to slight drift conditions. Ground rigs cover 3 to 5 acres per hour and require 1-2 persons to complete the operations. (Personal communication from farm advisors).

Tanks for fixed-wing aircraft range from 240-320 gallons and for helicopters 60-250 gallons. Aircraft applications range from 15 to 30 gallons per acre. Chemical sprays are pre-mixed and pumped into aircraft tanks (a closed system with powder box used by one applicator interviewed) (Medlock Dusters, 1980). With most aircraft the pilot is in an enclosed cab and sprays are applied during periods of no to slight drift conditions. Aircraft can cover 40-50 acres per hour and need 4 persons to complete operations. Helicopter applications may take less time.

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Ground rig applications cost around 12-15 dollars/acre (100 gallons applied) (Crop Mgmt. Co., 1980). Applications by air cost $9.00/acre (15 gal/acre) and $10.25/acre (20 gal/acre) (Medlock Dusters, 1980).

For ground applications (both open and closed cab) full spray clothes including hat, pants, and jacket are usually worn although not required by the product label. There are no restrictions on re-entry levels. Captan is applied in February and March. Harvest does not take place until August and September.

The following is a list of post-pesticide-treatment activities and field operations. One worker per operation in the field is required except during aircraft application of chemicals.

Operation	February		March	April	May	Per season (March-July)
	Time in orchard per acre (minutes) 1/					
Frost control						
Wind maching	0-5		0-5	0	0	
Irrigation (flash) (sprinkler)	0-10		0-10			
Insect control						
NOW					12-15	
Weed control						
Flailing	16		16	16	16	6-10X
Spot spray			16			
Discing	20	or	20			
Irrigation						
Sprinkler			5-10	5-10	10-12X	
Drip			5-10	5-10	5-10	continuous
Flood			15-30	15-30	15-30	7-10X
Pollination						
Bee removal	5		15	5		

1/ One worker/operation
(Personal communication with farm advisors/growers, 1980)

IV. Exposure Hazards

There are no proven hazards to individuals during application of captan or at field re-entry. Hulls may not be fed to dairy animals or animals being finished for slaughter if captan is used within 12 days of harvest (Ortho, 1979).

V. Role of Captan

Captan is used in combination with benomyl to control brown rot blossom blight although no evidence has been provided that combination treatments delay development of benomyl-resistant strains of <u>Monilinia</u> or increase benomyl effectiveness. Benomyl-resistant strains of <u>Monilinia</u> or increase benomyl effectiveness. Benomyl-resistant <u>M</u>. <u>laxa</u> has not been detected before or after the use of combination treatments (Ogawa et al., 1977). Captan is effective in controlling shot hole, leaf blight, and scab with no residues on hulls at harvest. See Table 1 for listing of registered fungicides for disease control.

There are no biological control methods for the almond diseases mentioned. Dormant applications (December or January) of sodium pentachlorophenate will reduce the number of sprays required for brown rot blossom blight and leaf blight. Sodium pentachlorophenate is an RPAR (RPAR, 1980). Cultural practices which decrease free moisture contact on plant parts will reduce infections from Coryneum. Such could be accomplished by low angle sprinklers (Wilson and Ogawa, 1979 p. 74).

VI. Alternative registered chemicals (see Table 1)

Table 1. Registered alternative fungicides for control of brown rot, shot hole, leaf blight, and scab on almonds.

	Brown Rot		Shot Hole			Leaf Blight		Scab	
Fungicides	Pc 1/	Bl 1/	Pc	Pf 1/	5 wk after Pf	Pf	5 wk after Pf	Pf	5 wk after Pf
Registered use 2/									
Benomyl	x	x	-	-	-	-	-	-	-
Coppers	x	x	x	-	-	-	-	-	-
Maneb	x	x	x	x	x	-	-	-	-
Captan	x	x	x	x	x	x	x	x	x
Ziram	-	-	x	x	x	x	x	x	x
Wettable sulfur	x 1/	x 1/	-	-	-	-	-	x	x
Alternatives (relative effectiveness) 3/									
Assumption 1 - no captan									
Benomyl	1								
Coppers	3	3							
Maneb	2	2							
Ziram			1	1	1	1	1	1	1
Wettable sulfur	4	4	1	1					
Assumption 2 - no benomyl or captan									
Coppers	2	2							
Maneb	1	1							
Ziram			1	1	1	1	1	1	1
Wettable sulfur	3	3						1	1
Assumption 3 - no ziram									
Benomyl	1	1							
Coppers	3	3							
Maneb	2	2							
Captan	2	2	1	1	1	1	1	1	1
Wettable sulfur	3	3						1	1
Assumption 4 - no benomyl or ziram									
Copper	3	3							
Maneb	2	2							
Captan	1	1	1	1	1	1	1	1	1
Wettable sulfur	4	4						1	1

Pc = popcorn; Bl = bloom; and Pf = petal fall

2/ Label registrations
3/ Relative effectiveness: 1 = best

[illegible]
[illegible]

[illegible]

Additional information on the alternative fungicides are:

1) Benomyl is on the RPAR and is used only against brown rot blossom blight. Monilinia fructicola strains resistant to benomyl have been detected in peach, nectarine, and cherry orchards, but not in almond orchards (Ogawa, et al, 1977; Szkolnik, et al., 1978);

2) Coppers are less effective in controlling brown rot blossom blight and shot hole; they can also cause phytotoxicity to leaves.

3) Maneb is effective against brown rot blossom blight but less effective than captan for shot hole. Maneb is an RPAR.

4) Wettable sulfur is effective only against scab. Ziram is more effective than captan for shot hole control, and can effectively control leaf blight and scab. Ziram is not effective against brown rot blossom blight.

Reference for table and notes, English et al., 1958.

VII. Summary

For brown rot blossom blight, shot hole, leaf blight, and scab, captan is the only registered fungicide with broad spectrum activity capable of controlling all four diseases. When used on foliage, captan's short residual life prevents the presence of residues at harvest. Under heavy disease pressure, benomyl is more effective than captan for brown rot blossom blight control, and ziram is more effective for shot hole control. Under low to moderate disease pressure, as experienced in the central (Fresno) and southern (Kern) counties (where major almond acreages are located), captan can provide effective disease control without the use of benomyl or ziram.

[illegible]

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peach, nectarine, [illegible] cherry [illegible]

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effective against brown rot [illegible]

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and scab. Ziram is no [illegible] effective against brown rot blossom

[illegible] for table and notes. [illegible] et al. [illegible]

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heavy disease pressure, benomyl is more effective than

rown rot blossom blight control, and ziram is more effective

control. Under low to moderate disease pressure, as

in the central [illegible]

[illegible]

The exposure of captan to humans is limited because it is used only from bloom to 5 weeks after petal fall. Field operations at this time are restricted to frost control, weed control, irrigation, and bee pollination. By harvest time residual captan is not present.

Captan is applied by ground airblast rigs and aircraft, at which time precautions are taken to avoid excessive exposure to applicators.

Data gaps

1. Effectiveness of captan dust on almonds to control brown rot blossom blight.
2. Benefits of benomyl plus captan combinations in preventing or delaying development of benomyl-resistant strains of *Monilinia laxa* or *M. fructicola*.
3. Biological and/or cultural controls for brown rot, shot hole, leaf blight and scab.
4. Comparison of ziram and maneb with captan for control of brown rot blossom blight.
5. Crop losses data from the diseases brown rot blossom blight, coryneum blight, leaf blight and scab.

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CORN & SMALL GRAINS

I. Commodity Information

The grains covered in this report include wheat, oats, barley, rye, corn, and sorghum. As a whole this group of grains is the most valuable food source in the U.S. and the world. Wheat is the most important world crop with a 1970-72 average production of 337 million metric tons (10). It is the major staple for nearly 40 percent of the world's population. All states except Louisiana, Florida, Alaska, Hawaii and those in New England are commercial wheat producers. Over 80 percent of the world's wheat is produced in North America. Corn ranks third, following wheat and rice, in the world production of cereal crops. About 45 percent of the world's corn is grown in the United States. Corn is grown in every state except Alaska and on half of all cropped farms in the United States.

Barley ranks fourth in area among world crops harvested. The leading states in barley production are North Dakota, California, Minnesota, and Idaho. The majority of U.S. barley is used for malt production. The remainder is used for seed, food, or feed. Sorghum ranks fifth in acreage and production among all world crops. The leading states in grain sorghum production are Texas, Kansas, Nebraska, Oklahoma, and Missouri. It is used primarily for silage or fodder in the United States.

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[illegible] and rice, in the world [illegible]

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corn in every state except Alaska [illegible]

the United States.

[illegible] in barley production are North Dakota, California, [illegible]

and Idaho. The majority of U.S. barley is used for [illegible]

[illegible] remainder is used for seed, food, [illegible]

[illegible] and production among all world crops. [illegible]

[illegible] grain sorghum production are Texas, Kansas, Nebraska, [illegible]

souri. It is used primarily for silage or fodder [illegible]

Oats and rye are grown for forage, feed grains, and alcohol. Their acreage is decreasing slightly due to increased grain production in wheat and corn.

Until recently, chemical disease control was not commonly practiced with any of the above mentioned crops. With the large acreages involved and the cost of pesticides, it was not considered economically feasible to use chemical disease controls. However, all seed was generally treated as a precautionary measure to insure optimum plant stands.

II. Pest Information

a. Geographic distribution

In general, all of the diseases or pathogens to be discussed are either seed- or soil-borne. In any case, the pathogens attack the plant when it is most vulnerable, in its seedling stage. As the seed germinates, exudates are released which stimulate the pathogens in the seed rhizosphere or on the seed surface. Disease at this stage results in a direct loss, generally the complete destruction of the seedling, causing a reduction in stand. Since the pathogens of seed-borne diseases are carried with the seed there is no geographic limitation to the disease. With regard to the soil-borne organisms, they are generally located wherever the crop is grown, and are capable of living as saprophytes in the soil on debris for many years. Thus rotations are generally not considered valid control practices by themselves.

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Information

...a ... distribution

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b.- Losses in absence of control

The losses caused by these seedling diseases are generally significant in that there is a general reduction in plant stand. This may contribute a significant yield loss in many years, especially if the seed is not certified or of high quality. This has been substantially documented in a report by Stapel, listed in the text on seed pathology (15).

c. Life cycles

We will consider the pathogens separately noting the specific crops involved.

III. *Pythium* Species

Unlike the other pathogens that will be covered, the *Pythium* spp. generally thrive in wet, cool weather. This set of conditions is unfavorable for seed germination and seedling development of any crop. The pathogen causes a seed rot and root rot. The disease is thoroughly discussed by Hoppe (6) on corn and wheat, oats and barley by Kilpatrick (8) and Cook (3).

About 12 species of *Pythium* are known to cause root rot, seed rot, and damping-off. Species documented as wheat, oat, barley and rye pathogens are *P. arrhenomanes* Drechs., *P. graminocila* Subr., *P. aphanidermatum* (Edson) Fitz., *P. volutum* Vant. & Tru. and *P. myriotylum* Drechs. *Pythium graminicola* and *P. arrhenomanes* are the major *Pythium* species on corn and sorghum. A disease cycle of *Pythium* is illustrated in the text on wheat by Wiese (20).

IV. *Fusarium* Species

Like *Pythium*, many species of *Fusaria* are responsible for root and crown rots of cereal grains. The species identified are: *F. roseum*, *F. cerealis* (Cke.) Snyder & Hansen on all cereals, *F. moniliforme* (Sheld.) Snyder & Hansen on corn and sorghum, *F. culmorum* (Smith) Sacc., *F. avenaceum* (Corda ex Fr.) Sacc., and *F. nivale* (Fr.) Ces. on wheat, oats and barley. *Fusarium nivale* is a cool temperature fungus and fits into the snow mold category. The rest of the species can tolerate a wider range in temperatures. The fungus lives on debris in the soil but is also carried on the seed. In the case of corn seedling blight, the major inoculum source is infected seed. Losses are generally highest in areas where humidity is high.

V. *Rhizoctonia solani*

Rhizoctonia solani Kuhn is often associated with root and crown rots of wheat, oats, barley, rice and corn especially in warmer climates. On wheat, captan is used throughout the U.S. on corn and sorghum seed.

a. Acres or units treated

The largest use of captan for seed treatment is on corn seed. Approximately 100 percent of all acres planted in the U.S. are planted with treated seed and this treatment is some form of captan. In 1978, 80 million acres were planted (1). The small grain cereals (wheat, oats, barley and rye) were planted on 95 million acres in 1978. Based on information obtained from chemical

companies and various state agencies, only 2 percent or 1.9 million acres of small grains were treated in 1978. Sorghum acreage was 16 million acres and 95 percent of the sorghum seed or 1.5 million acres were treated in 1978.

b. Pesticide product

1. Formulation used

In general, only two types of formulations are used by the seed industry. These include wettable powders which are applied as slurries or flowables. The trend in the last five years has been toward flowables since there is no dust involved in the mixing process. However, flowables cannot be ordered in large volumes since they do not store as well as powders. There is very little planter box seed treatment since the seed industry generally treats all seed. However, a few states will list plant box dusts in their recommendations. Formulations are listed in Table 1.

2. Package sizes

The flowable chemical comes in 5 gallon containers. The wettable powders are sold in fiberboard cartons, usually 50 lb. in size. However, Chevron Chemical Co. does offer a 100 lb. size.

3. Cost per pound of active ingredients

This information is presented in Table 1.

c. Application techniques

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are listed in Table 1.

Package Sizes

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ever, Chevron Chemical Co. also offers a ... 10

1. Method and time application

Seed is generally treated by the seed company or grainery following harvest, when seed stocks are evaluated and seed sales are estimated. This is generally an off-season chore. Most seed is treated with a mist-o-matic treater followed by a hex drum for spreading out the chemical. The second most used applicator is a panogen drum treater.

2. Application rates

a)	Corn	0.7 - 2.0 oz.	a.i./100 lb.	seed
	Sorghum	0.8 - 2.3 oz.	a.i./100 lb.	seed
	Barley	0.6 - 1.9 oz.	a.i./100 lb.	seed
	Oats	0.6 - 2.8 oz.	a.i./100 lb.	seed
	Wheat	0.6 - 2.0 oz.	a.i./100 lb.	seed
	Rye	0.6 - 1.6 oz.	a.i./100 lb.	seed

b) Frequency and intervals between application.

Only one application.

3. Application equipment used

Two types of applicators are used in the seed industry. Generally the panogen drum type liquid seed treater is more common. The machine is provided with an adjustable hopper to control seed flow, devices for metering seed and fungicide, and an inclined drum with baffles at the discharge to control the time the seed is in the drum. The wettable powders may be applied as heavy suspension in water.

The second type of treater is known as a continuous operation mist treater, the best known brand being the Mist-O-Matic seed treater. The machine controls seed and fungicides plus breaks the fungicide into small droplets with rapidly spinning discs. Both of these units are completely enclosed and the chemicals are added to large drums where they are diluted with water. Workers only come into contact with the chemical during the mixing operation, which is done only once or twice a day. Using a slurry and a panogen treater, 600 bushels can be treated per hour. With a liquid mist treater the capacity is similar. Generally only one individual is responsible for mixing solutions and monitoring applications.

Planter box treatments are generally dust applications in a planter. One worker, generally the driver, is involved with the application. He is exposed to the chemical when filling

Application equipment used:

Two types of applicators are used in the seed industry.

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... treater, 600 bushels can be treated per hour. With

... mist treater the capacity is similar. Generally only

the planter box. However, this method is not used extensively.

4. Precautionary measures

a) Protective equipment used.

Workers are required to wear respirators and gloves while handling the chemical in seed operations. Planter box operations require respirators, however, this cannot be carefully enforced.

VI. Evaluation of exposure and hazards associated with registered uses

Workers are not generally exposed to the pesticide during seed treating operations except when adding fungicide to the large mixing tanks. Most of the processes including the bagging are automated. Even in small-scale operations automation has taken over. The next possible exposure period occurs when growers get the seed and open the bags. At this stage seed is dumped into planters. Some of the applications may give off dust during this period. Care must also be taken so that the seed does not enter any feed supply. A dye added to the seed treatment provides a means of warning here.

VII. Pest Management Programs

These do not apply in regard to seed treatments. Growers have regarded treatment as a cheap means of insuring a uniform plant stand and good yields.

VIII. Information on other registered pesticides used for this commodity

There are many alternatives to captan which are listed in many states. The major chemicals are listed in Tables 2 and 3.

Captan is a very effective corn seed treatment. In a series of tests by Mohammed & Fathi (11,12,13,14) captan was shown to be the most effective fungicide seed treatment as compared to maneb, zineb or terrazole, registered alternatives. The percentage of seedling emergence was always greater with captan treated seed.

IX. Economic impact of loss of captan

a. Introduction

The most severe impact of loss would be felt by the corn and sorghum seed industry. To date, only captan provides the wide spectrum pathogen control needed, especially in cool-wet conditions. The only materials demonstrated to be more effective were the organic mercury compounds, now removed from the market. The only currently available material that comes close to captan in effectiveness is thiram. Thiram tends to be more irritating than captan and this has discouraged its use. In talking with the seed producers, especially the large corn seed companies, the feeling

was that captan was the only available chemical which did an adequate job of covering the seed, controlling a wide range of organisms, especially *Pythium*, and had a low cost. If it were removed from the market, stands would be reduced, generally due to *Pythium*. This would result in less seed treatment or greatly increased seed prices. Eventually this could be passed on to the consumer, but the grower would suffer the loss the most. Small grains require the use of fungicides which control smut disease and seed decay of seedling blight. Carboxin is now widely used as a seed treatment on wheat, barley, and oats to control smut diseases. However this fungicide gives poor control of most other fungi. Therefore this fungicide is combined with a broad spectrum protective type material such as captan or thiram. The use of carboxin in combination is also important since fungi have developed resistance to this fungicide where it has been used alone. There are several new materials which may replace carboxin in the market but these will also require the use of broad spectrum protective fungicides. The major impact would definitely be on the corn and sorghum industry.

In planting corn, the goal is to have all or most of the crop planted by the date beyond which decreased yields would normally result if planting is delayed. This date is called the "optimum date". The optimum date for planting in Illinois, for example, is earlier in southern Illinois than in central or northern Illinois. Corn that is planted two or three weeks before the optimum date may not yield as much as that planted on or near the optimum date;

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however, it normally will yield considerably more than that planted two weeks or more after the optimum date (Table 4).

There are several hazards associated with early planting including the danger of losses due to diseases caused by both seed and soil-borne pathogens. Seed treatments such as captan have greatly reduced this hazard. Captan improves seedling stands, especially if the seed is not high in quality. This has been demonstrated as evidenced in the special report compiled by Moore and Nyvall (2).

Pedersen (17) also showed that there was a significant reduction in stand counts in the absence of captan as a seed treatment in two Illinois locations (Tables 5, 6). Seed was first planted when soil temperatures were near 50 degrees F. Following planting, the weather was very cold and wet and most hybrids did not emerge for at least two weeks. When the soil temperature reached over 60 degrees F., the differences in emergence were greatly reduced.

Although there is risk involved with early planting, it is a highly recommended practice (7) where the advantages outweigh the risks. The advantages of early planting include 1) higher yield, 2) drier corn in the fall, 3) greater control of the planting date, and 4) a greater choice of hybrids of differing maturity. Fungicide treatment of seeds is a necessity if early planting practices are employed. Loss of captan could seriously affect early planting of corn, since it is the most effective corn seed treatment and is

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recommended in 19 states.

Along with the move to early planting there has been a rapid acceptance of no-till farming. This methodology provides an energy savings but provides increased disease potential, with abundant inoculum greater on or near the soil surface in the no-till situation. The poor seedbed and associated stresses puts an even greater emphasis on seed treatment. Captan appears to adequately protect seed in no-till operations. If captan were removed from the market, much research would have to be funded to search out a possible new seed treatment.

With no suitable alternatives in the wings, it could be a costly blow to agriculture. Reduced stands would result in reduced yields per acre and reduce a commodity group's production which is most vital to the economic health of this nation, especially in terms of export.

Table 1. Major formulations of captan used for seed treatment.

Formulation	Percent a.i.	Product type	Package size	Distributor cost	Cost/gal. (lb.)a.i.	Cost/100 lb. /application	Company
Captan 80 SP	80.0	WP	50 lb	131.00	3.27	0.28 - 0.40	Stauffer
Captan-Methoxychlor 75-2 SP	75.0	WP	50 lb	131.00	3.47	0.29 - 0.42	Stauffer
Captan 4 FL	40.0	FL	5 gal	14.49	7.24	0.04 - 0.08	Stauffer
Captan-Methoxychlor 37.5-1.5 FL	37.5	FL	5 gal	15.91	8.83	0.05 - 0.10	Stauffer
Orthocide 75 SP	75.0	WP	100 lb.	317.00	4.22	0.32 - 0.45	Ortho
Orthocide-Methoxychlor 75-5 SP	75.0	WP	100 lb	351.00	4.68	0.38 - 0.49	Ortho
Orthocide 4 FL	37.2	FL	5 gal	15.45	8.30	0.04 - 0.08	Ortho
Captan 30 DD	30.0	FL	5 gal	15.00	10.00	0.04 - 0.06	Gustafson
Orthocide-Vitavax 20-20	20.0	WP	10 lb	-	-	-	Ortho

Table 2. Corn seed treatment alternatives to captan.

	Package Size	Distributor Cost	Cost/gal. (lb.)a.i.	Cost/100 lb. /application
Carboxin 200	5 gal.	120.00	70.59/gal.	0.56
Carboxin 34	5 gal.	240.00	141.18/gal.	1.13
Thiram 42-5	5 gal.	80.00	38.10/gal.	0.38
Busan	5 gal.	155.00	103.33/gal.	3.63
Polyram	50 lb.	75.00	1.87/lb.	0.28 - 0.39
Dexon	50 lb.	772.50	22.07/lb.	0.39 - 0.77

Also registered for use and viable alternatives

Captafol

PCNB

Terrazole

Maneb

Others

Dichlone

Difolatan

Zineb

Table 3. Cereal seed treatment alternatives to captan.

Alternative	Rate	Package size	Distributor cost	Cost/gal. (lb.)a.i.	Cost/100 lb. /application
Carboxin 200 (17-17)	3 oz/cwt.	5 gal.	120.00	70.59/gal.	0.56
Carboxin 34	3 oz/cwt.	5 gal.	240.00	141.18/gal.	1.13
Thiram 42	1/2 oz/cwt.	5 gal.	80.0	38.10/gal.	0.09 - 0.19
Busan 30	7 1/2 fl oz/bu.	5 gal.	155.00	103.33/gal.	2.54 - 5.45
Polyram 80	1.67 AI/bu.	50 lb.	75.00	1.87/lb.	0.43 - 0.58
Dexon 70	.4-.8 oz/100 cwt.	50 lb.	772.50	22.07/lb.	0.39 - 0.77

Also registered and are possible efficacious alternatives

Captafol

Maneb

Terrazole

Mancozeb

PCNB

HCB

Zineb

Table 4. Effect of planting date on yield.*

	Northern Illinois	Central Illinois	Southern Illinois
Late April	---	156	102
Early May	151	162	105
Mid May	150	---	82
Early June	100	133	58

*3-year average at each location, from Illinois Agronomy Handbook, 1978

Table 5. Effect of captan seed treatment on corn yield and plant stand at different planting dates and stands.

Hybrid	Planted 1000's/A	5/8 Planting Date			
		Treated		Untreated	
		Stand 1000's/A	Yield bu/A	Stand 1000's/A	Yield bu/A
LH38xA632	18	14.90	127.2	9.38	80.1
	21	15.39	129.6	10.89	94.7
	24	18.73	150.3	14.17	114.3
Mo17xA634	18	15.10	135.8	13.30	114.1
	21	18.53	158.1	15.33	130.7
	24	21.78	166.6	19.31	145.2
		5/19 Planting Date			
		Treated		Untreated	
		Stand 1000's/A	Yield bu/A	Stand 1000's/A	Yield bu/A
LH38xA632	18	14.35	120.9	14.11	106.5
	21	16.55	129.2	14.78	113.5
	24	20.36	119.1	19.54	125.8
Mo17xA634	18	17.54	104.4	15.36	143.3
	21	19.49	138.0	18.50	128.9
	24	21.43	117.3	21.58	117.7

Data: DeKalb 1981. W.L. Pedersen and D.G. White

Table 6. Effect of captan seed treatment on corn yield and plant stand at different planting dates and populations.

Hybrid	Planted 1000's/A	4/27 Planting Date			
		Treated		Untreated	
		Stand 1000's/A	Yield bu/A	Stand 1000's/A	Yield bu/A
MO17xB73	18	14.08*	179.5	13.50	149.2
	21	17.39*	177.0*	16.26	150.3
	24	16.41	189.0*	15.54	154.5
Mo17xA634	18	15.54	150.0	14.08	134.4
	21	18.09	147.0	14.67	133.4
	24	19.11	149.9	16.99	143.0

		5/22 Planting Date			
		Treated		Untreated	
Stand	Yield	Stand 1000's/A	Yield bu/A	1000's/A	bu/A
Mo17xB73	18	16.80*	129.6	15.62	140.2
	21	18.59	130.1	18.73	133.5
	24	21.14	136.2	22.30	133.5
Mo17xA634	18	16.93	134.7	15.10	126.4
	21	18.73	129.8	17.22	119.7
	24	22.30	127.3	19.46	113.4

*significant at 0.05%.

Data: Urbana 1981. W.L. Pedersen and D.G. White.

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RICE

I. Commodity Information

Rice is an important cash crop in the United States. A source of human food, livestock feed, and by-products used for industrial purposes, rice production occurs chiefly in California, Texas, Louisiana, Mississippi, Arkansas and Missouri. About 3 million acres were planted in 1979, producing an estimated 1.3 billion dollars worth of rice (Table 1). Production practices in the United States require relatively large-scale, mechanized capabilities; thus, rice plantings are restricted to farming operations which have those capabilities.

II. Pest Information

Rice diseases that are controlled by captan are seed and seedling diseases. The incitants of these diseases are commonly present in the soil wherever rice is grown and may be on or in the planting seed. When a fungicide is not used for controlling these diseases, planted seed may decay, or seedlings which develop may be reduced in vigor or killed by seedling diseases. Reduced seedling vigor and/or stands may result in reduced yields, depending on the severity of the diseases. Low vigor and reduced seedling stands can result in the inefficient utilization of herbicides and fertilizers. Overall production costs can be increased by additional weed control expense or even the cost of replanting. Changes in management practices and delayed crop maturity or harvest can add to production costs.

Several fungi may be associated with seed and seedling diseases. These fungi include species of *Achyla*, *Aspergillus*, *Curvularia*, *Fusarium*, *Helminthosporium*, *Penicillium*, *Pyricularia*, *Pythium*, *Rhizoctonia*, and *Sclerotium*. Other fungi can also be involved in the seed and seedling disease complex.

III. Captan Use

a. Geographic areas of use

Captan is used throughout the rice growing areas of the United States to help control seed and seedling diseases.

b. Acres or units treated

Information is not available to use as a reliable basis for making an estimate of usage.

c. Pesticide product

Product information is given in Table 2.

d. Application techniques

All of the captan containing products listed in Table 2 are applied to planting seed. The Captan 25 Seed Protectant is applied as a planter box treatment by growers. The other products are applied by commercial seed treaters as slurry treatments. Labelled rates are given in Table 2.

No special equipment is involved in the use of captan as a planter box treatment, measured quantities of dust formulations being added to the seed in a planter box or pre-mixed with

the seed in some manner. Commercial seed treating equipment simply mixes a known quantity of captan with a known quantity of seed in a repeating, continuing operation. Protective equipment and/or clothing are not usually used by workers during the planting operation. Information is not available on the use of protective equipment and/or clothing by workers in commercial seed treating operations.

e. Field operations after fungicide application

There are no field operations related to post-pesticide treatment activities.

IV. Exposure Hazards

a. General public

The registered uses of captan as a seed treatment for rice does not result in an exposure hazard to the general public.

b. Workers in commercial seed treating operations

Persons who work in commercial seed treating operations may be exposed to hazards related to inhalation of the fungicide or skin contact with it. All of the products used on rice are applied as slurry treatments, and therefore, exposure is considered minimal.

c. Field applicators

Commercially treated seed present little hazard to workers involved in the planting operation. Some hazard to workers from dust particles exists when planter box treatments are transferred

in the field from the fungicide containers to the planter box or mixing container. These hazards are minimized or eliminated when recommended procedures are followed.

V. Role of Captan

Captan is used in every rice producing state as a fungicide seed treatment to help control seed and seedling diseases of rice. It is compatible with several other fungicides and several insecticides, and is used in combination with them in order to protect seed against insects as well as against a broad spectrum of microorganisms. One of the principal seed fungicides used in the United States, captan is relatively inexpensive and competitive in this respect with alternative fungicides.

Breeders who have worked with various aspects of seed and seedling vigor have improved this character in rice plants. Seed and seedling health may also be improved by following, wherever possible, such basic practices as crop rotation, sanitation, and recommended crop management. Nevertheless, the fundamental factors--soil, seed, microorganisms, climate--involved in seed and seedling diseases are of a nature such that it appears that in most planting situations a fungicide, such as captan, will be needed.

VI. Alternative Registered Fungicides

a. Planter box treatments

There are few viable alternatives to captan as a planter box

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[illegible] with several other fungicid[illegible]

[illegible] in combination with them [illegible]

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[illegible] seed fungicides used in the United [illegible]

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[illegible] can be improved by fumigation [illegible]

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[illegible] volved in seed and seedling [illegible]

[illegible] that in most planting situations [illegible]

treatment. Many of the commonly used formulations employ captan alone or in combination with other fungicides. Other widely used products contain PCNB which has an uncertain future because it is now in the RPAR procedure. Thiram is a third material which has some use as a planter box fungicide.

b. Seed treatments

Registered fungicides which may be used on rice instead of captan are listed in Table 3. Although registered not all of the products listed are available. Marketing realities may result in a limited number of fungicides being available to growers in a specific area. As noted above, PCNB containing products are not viable alternatives because of the uncertainty related to their involvement in the RPAR procedure. Nevertheless, several alternatives to captan are registered. These alternatives are generally most effective when used in combination with other fungicides.

VII. Summary

Captan is used throughout the rice growing states as a seed treatment. The fungicide is used as a planter box treatment and as a seed processor-applied slurry treatment. The several registered alternatives to captan are most effective when used in combination with other fungicides.

Table 1. Estimated acreage and value of cotton, peanuts, rice, and soybeans planted in the United States in 1979. 1/

Commodity	Acres	Value
Cotton	13,900,000	5,029,194,000
Peanuts	1,549,000	821,313,000
Rice	3,070,000	1,325,670,000
Soybeans	71,700,000	13,875,465,000

1/ Source: Acreage, Crop Reporting Board, Economics, Statistics, and Cooperatives Service, USDA, Washington, DC (released June 28, 1979).

Table 2. Principal captan-containing products used on rice.

Product 1/	% Captan (a.i.)	Formulation 2/	Package size	Cost 3/ (lb, gal form.)	Labelled rate (unit/unit)
Captan 4F (Stauffer)	38.5	F	5 gal	15.50	3-6 fl oz/cwt
Captan 75 (Stauffer)	75.0	WP	50 lb	2.55	2 1/2 oz/cwt
Captan 80 (Stauffer)	80.0	WP	50 lb	2.68	2 1/4 oz/cwt
Captan 25 Seed Protectant (Stauffer)	25.0	D	10 lb	1.28	14 oz/cwt
Orthocide 4F SP (Chevron)	•37.2	F	5 gal	18.00	3 2/5 fl oz/cwt
Orthocide 75 SP (Chevron)	75.0	WP	50 lb	3.13	2 1/2 oz/cwt

1/ Product manufacturers listed are Stauffer Chemical Company, Westport, Connecticut, and the Chevron Chemical Company, Richmond, California.

2/ D = dust; F = flowable; WP = wettable powder.

3/ Cost figures were provided by company representatives of the respective companies on May 13, 1980, and are subject to change and local variation.

Table 3. Registered fungicide alternatives for captan for use on rice.

Disease	Fungicide(s) /1
Seedling disease complex	Busan
	Carboxin
	Carboxin + Thiram
	Difolatan
	Dithane M-45
	Kocide
	Maneb + Zinc
	PCNB + ETMT (Terrazole)
	Thiram

1/ Common names used where possible.

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COTTON

I. Commodity Information

Cotton is the major fiber crop grown in the United States. Cotton lint is used in numerous textile products. Historically, the crop has been grown in the southern tier of the states from southern Virginia to California, including Tennessee, Kentucky, Missouri, Arkansas, and Oklahoma. Recently, cotton production has shifted westward with a reduction in acreage in the eastern-most states. Now the bulk of the crop is grown in Mississippi, Arkansas, Texas, Arizona, and California. About 14 million acres of cotton were planted in the United States in 1979 producing a crop valued at 5 billion dollars (Table 1). Nearly all of the crop is grown on commercial farms where modern cultural technology is used.

II. Pest Information

Cotton diseases that are controlled by captan are seed and seedling diseases. The incitants of these diseases are commonly present in the soil wherever cotton is grown and may be on or in the planting seed. When a fungicide is not used for controlling these diseases, planted seed may decay, or seedlings which develop may be reduced in vigor or killed by seedling diseases. Reduced seedling vigor and/or stands may result in reduced yields, depending on the severity of the diseases. Low vigor and reduced seedling stands can result in the inefficient utilization of herbicides and fertilizers. Overall production costs can

[illegible] is the major fiber crop [illegible] in the United States. Cotton
[illegible] in numerous textile products. [illegible]
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including Tennessee, Kentucky, Missouri, [illegible]
[illegible] cotton [illegible]
acreage in the eastern [illegible]
[illegible] Mississippi, Arkansas, Texas, Arizona, and California.
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a crop valued at 5 billion dollars [illegible]
is grown on commercial farms [illegible]

[illegible] are controlled by insects and weeds and [illegible]
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is not used for controlling these diseases, planted
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be increased by additional weed control expense or even the cost of replanting. Changes in management practices and delayed crop maturity or harvest can add to production costs.

Several fungi may be associated with seed and seedling diseases. These fungi include species of Alternaria, Ascochyta, Aspergillus, Colletotrichum, Fusarium, Penicillium, Pythium, Rhizoctonia, Rhizopus, Trichoderma, Thielaviopsis, and others. Xanthomonas malvacearum, the bacterial blight pathogen, can be a primary cause of seedling disease in some areas, and other bacteria can also be involved in the seed and seedling disease complex.

III. Captan Use

a. Geographic areas of use

Captan is used throughout the cotton growing areas of the United States to help control seed and seedling diseases.

b. Acres or units treated

Information is not available to use as a reliable basis for making an estimate of usage.

c. Pesticide product

Product information is given in Table 2.

d. Application technique

All of the captan-containing products listed in Table 2 are applied to the planting seed. The Captan-Terraclor, Isotox Seed Treater (F), and Soil Treater 3X formulations are applied

by growers. The other products are applied by commercial seed treaters as slurry treatments. Labelled use rates are given in Table 2.

No special equipment is involved in the use of captan as a planter box treatment, measured quantities of dust formulations being added to the seed in a planter box type or pre-mixed with the seed in some manner. Commercial seed treating equipment simply mixes a known quantity of captan with a known quantity of seed in a repeating, continuing operation. Protective equipment and/or clothing are not usually used by workers during the planting operation. Information is not available on the use of protective equipment and/or clothing by workers in commercial seed treating operations.

e. Field operations after fungicide application

There are no field operations related to post-pesticide treatment activities.

IV. Exposure Hazards

a. General public

The registered uses of captan as a seed treatment for cotton does not result in an exposure hazard to the general public.

b. Workers in commercial seed treating operations

Persons who work in commercial seed treating operations are exposed to hazards related to inhalation of the fungicide or

skin contact with it. All of the products used on cottonseed are applied as slurry treatments and, therefore, exposure is considered minimal.

c. Field applicators

Commercially treated seed present little hazard to workers involved in the planting operation. Some hazard to workers from dust particles exists when planter box treatments are transferred in the field from the fungicide containers to the planter box or mixing container. These hazards are minimized or eliminated when recommended procedures are followed.

V. Role of Captan

Captan is used in every cotton producing state as a fungicide seed treatment to help control seed and seedling diseases of cotton. Most planting seed are commercially-treated and planter box treatments are commonly used. Captan is compatible with several insecticides, and is used in combination with them in order to protect seed against insects as well as against a broad spectrum of microorganisms. One of the principal seed fungicides used in the United States, captan is relatively inexpensive and competitive in this respect with alternative fungicides.

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...ied as slurry treatments and, therefore, exposure is ...

Field applications

Co... ly treated seed present little hazard to ...
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Role of Captan

...tan is used in every cotton-producing State as a fungicide seed ...
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...least ... and competitive in this respect. ...

Breeders who have worked with various aspects of seed and seedling vigor have improved this character in cotton plants. Seed and seedling health may also be improved by following, whenever possible, such basic practices as crop rotation, sanitation, and recommended crop management. Nevertheless, the fundamental factors--soil, seed microorganisms, climate--involved are of a nature such that it appears that in most planting situations a fungicide, such as captan, will be needed.

VI. Alternative Registered Fungicides

a. Planter box treatments

There are few viable alternatives to captan as a planter box treatment. Many of the commonly used formulations employ captan alone or in combination with other fungicides. Other widely used products contain PCNB which has an uncertain future because it is now in the RPAR procedure. Thiram is a third material which has some use as a planter box fungicide.

b. Seed treatments

Registered fungicides which may be used on cotton instead of captan are listed in Table 3. Although registered, not all of the products listed are available. Marketing realities may result in a limited number of fungicides being available to growers in a specific area. As noted above, PCNB containing products are not viable alternatives because of the uncertainty related to their involvement in the RPAR procedure. Nevertheless, several alternatives to captan are registered. These alternatives are generally most effective when used in

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be improved by following, whenever possible, such [illegible]

as rotation, sanitation, and [illegible]

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[illegible] will be [illegible].

[illegible] Registered Fungicides

Planter box treatments

There are few [illegible]

treatment. [illegible]

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material which has [illegible]

Seed treatments

Registered fungicides which may be used [illegible]

[illegible] are listed in Table 3. [illegible]

the products listed are [illegible]

with in a limited number of fungicides [illegible]

[illegible] in a specific [illegible]

[illegible]

combination with other fungicides.

VII. Summary

Captan is used, usually in combination with other fungicides or insecticides, in every cotton producing state as a seed treatment. Captan is used as a planter box treatment and as a seed processor-applied seed treatment. Most seed used for planting are treated by commercial processors and planter box treatments are also commonly used. There are few readily available alternatives to captan. The available alternatives are most effective when used in combination with other fungicides.

Table 1. Estimated acreage and value of cotton, peanuts, rice, and soybeans planted in the United States in 1979. 1/

Commodity	Acres	Value
Cotton	13,900,000	5,029,194,000
Peanuts	1,549,000	821,313,000
Rice	3,070,000	1,325,670,000
Soybeans	71,700,000	13,875,465,000

1/ Source: Acreage, Crop Reporting Board, Economics, and Cooperatives Service, USDA, Washington, DC (released June 28, 1979).

Table 2. Principal captan-containing products used on cotton.

Product 1/	% Captan (a.i.)	Formulation 2/	Package size	Cost 3/ (lb, gal form.)	Labelled rate (unit/unit)
Captan 4F (Stauffer)	38.5	F	5 gal	15.50	1-1/2-5 fl oz/cwt
Captan 75W (Stauffer)	75.0	WP	50 lb	2.55	2 oz/cwt
Captan 80W (Stauffer)	80.0	WP	50 lb	2.68	2 oz/cwt
Captan-Methoxyclor 65-10 (Stauffer)	65.0	WP	50 lb	3.02	2-1/2 oz/cwt
Captan-Methoxyclor 75-2 (Stauffer)	75.0	WP	50 lb	2.67	2 oz/cwt
Captan-Thiram 43-43 (Stauffer)	43.0	WP	50 lb	3.13	5 oz/cwt
Captan-Terraclor 30-30 (Stauffer)	30.0	D	25 lb	2.39	1 lb/A
Orthocide 4F SP (Chevron)	37.2	F	5 gal	18.00	3 fl oz/cwt
Orthocide 75 SP (Chevron)	75.0	WP	50 lb	3.13	2 oz/cwt
Isotox Seed Treater (F) (Chevron)	25.0	D	1 lb	7.35	8 oz/cwt
Orthocide Methoxyclor 75-3 SP (Chevron)	75.0	WP	50 lb	3.39	2 oz/cwt
Orthocide Methoxyclor 75-5 SP (Chevron)	75.0	WP	50 lb	3.47	2 oz/cwt
Soil Treater 3X (Chevron)	30.0	D	20 lb	2.54	1 lb/A

1/ Product manufacturers listed are Stauffer Chemical Company, Westport, Connecticut, and the Chevron Chemical Company, Richmond, California.

2/ D = dust; F = flowable; WP = wettable powder.

3/ Cost figures were provided by representatives of the respective companies on May 13, 1980, and are subject to change and local variation.

[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Table 3. Registered fungicide alternatives for captan for use on cotton.

Disease	Fungicide(s) 1/
Seedling disease complex	Busan
	Captafol
	Carboxin + Thiram
	Chloroneb
	Chloroneb + Busan
	Chloroneb + Thiram
	Dexon
	Dexon + Chlorothalonil
	Dexon + PCNB
	Maneb + Zinc
	PCNB
	PCNB + ETMT (Terrazole)
	PCNB + Polyran
	Thiram
	Zineb

1/ Common names used where possible.

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3. Kipps, M. Smith. 1970. Production of Field Crops. McGraw Hill Book Company, New York. 790 pp.

4. Martin, J. H. and W. H. Leonard. 1967. Principles of Field Crop Production. The MacMillan Company, New York. 1044 pp.

SOYBEANS

I. Commodity Information

A major oil crop in the United States, soybeans provide human and livestock food and products used in industrial manufacturing. Soybeans are grown in more than half the states, mostly from the mid-section of the country eastward. However, production is concentrated in the mid-western states and along the Mississippi River southward into Louisiana. In 1979, nearly 72 million acres of soybeans were planted. The estimated value of soybean production was about 14 billion dollars (Table 1). Suitable for large scale mechanical production, the majority of soybeans are grown on commercial farms.

II. Pest Information

Soybean diseases that are controlled by captan are seed and seedling diseases. The incitants of these diseases are commonly present in the soil wherever soybeans are grown and may be on or in the soybean planting seed. When a fungicide is not used for controlling these diseases, planted seed may decay and seedlings which develop may be reduced in vigor or killed by seedling diseases. Reduced seedling vigor and or stands may result in reduced yields, depending on the severity of the diseases. Low vigor and reduced seedling stands can result in the inefficient utilization of herbicides and fertilizers. Overall production costs can be increased by additional weed control expense or even the cost of replanting. Changes in management practices and

delayed crop maturity or harvest due to the effects of seedling diseases can add to production costs.

Several fungi may be associated with seed and seedling diseases. These fungi include _Alternaria_, _Cercospora_, _Curvularia_, _Helminthosporium_, _Penicillium_, _Phytophthora_, _Pythium_, _Rhizoctonia_; _Rhizopus_, and _Sclerotium_. Other fungi, and bacteria, can also be involved in the seed and seedling disease complex.

III. Captan Use

a. Geographic areas of use

Captan is used throughout the soybean growing areas of the United States to help control seed and seedling diseases.

b. Acres of units treated

Information is not available to use as a reliable basis for making an estimate as usage.

c. Pesticide product

Product information is given in Table 2.

d. Application techniques

All of the products in Table 2 are applied to planting seed. The Captan Moly, Isotox Seed Treater (F), Soil Treater 3X, and Soybean Seed Protectant (MO) formulations are applied as planter box treatments by growers. The other products are applied by commercial seed treaters as slurry treatments. Labelled use rates are given in Table 2.

No special equipment is involved in the use of captan as a planter box treatment, measured quantities of dust formulations being added to the seed in a planter box or pre-mixed with the seed in some manner. Commercial seed treating equipment simply mixes a known quantity of captan with a known quantity of seed in a repeating, continuing operation. Because treatment of soybeans with a fungicide such as captan makes the soybean unsuitable for use as a food for humans and livestock and the germination rate of soybeans decreases with long-time (from one growing season to the next) storage, commercial seed treatment has usually been limited to some kind of treatment on order arrangement. Protective equipment and/or clothing are not usually used by workers during the planting operation. Information is not available on the use of protective equipment and/or clothing by workers in commercial seed treating operations.

e. Field operations after fungicide application

There are no field operations related to post-pesticide treatment activities.

IV. Exposure Hazards

a. General Public

The registered uses of captan as a seed treatment for soybean does not result in a exposure hazard to the general public.

b. Workers in commercial seed treating operations

Persons who work in commercial seed treating operations are exposed to hazards related to inhalation of the fungicide or skin contact with it. All of the products used on soybeans are applied as slurry treatments and, therefore, exposure is considered minimal.

c. Field applicators

Commercially treated seed present little hazard to workers involved in the planting operation. Some hazard to workers from dust particles exists when planter box treatments are transferred in the field from the fungicide containers to the plant box or mixing container. These hazards are minimized or eliminated when recommended procedures are followed.

V. Role of Captan

Captan is used in every soybean producing state as a fungicide seed treatment to help control seed and seedling diseases of soybeans. It is compatible with several insecticides, and is used in combination with them in order to protect seed against insects as well as against a broad spectrum of microorganisms. Plant nutrition products are also used in combination with captan. One of the principal seed fungicides used in the United States, captan is relatively inexpensive and competitive in this respect with alternative fungicides.

Breeders who have worked with various aspects of seed and seedling vigor have improved this character in soybean plants. Seed and seedling health may also be improved by following, whenever possible, such basic practices as crop rotation, sanitation, and recommended crop management. Nevertheless, the fundamental factors--soil, seed microorganisms, climate --involved are of a nature such that it appears that in most planting situations a fungicide, such as captan, will be needed.

VI. Alternative Registered Fungicides

a. Planter box treatments

There are few viable alternatives to captan as a planter box treatment. Many of the commonly used formulations employ captan alone or in combination with other fungicides. Other widely used products contain PCNB which has an uncertain future because it is now in the RPAR procedure. Thiram is a third material which has some use as a planter box fungicide.

b. Seed treatments

Registered fungicides which may be used on soybeans instead of captan are listed in Table 3. Although registered, not all of the products listed are available. Marketing realities may result in a limited number of fungicides being available to growers in a specific area. As noted above, PCNB containing products are not viable alternatives because of the uncertainity related to their involvement in the RPAR procedure. Nevertheless, several alternatives to captan are registered. These alternatives are generally most effective

when used in combination with other fungicides.

VII. Summary

Captan is used, either alone or in combination with insecticides and plant nutrition products, throughout the soybean growing areas of the United States as a seed treatment. Captan is used as a planter box treatment and as a seed processor-applied seed treatment; however, because soybeans treated with captan can not be used as a food and because soybeans lose germinability in long-time storage, commercial seed treatment is usually limited to some kind of treatment on order arrangement. There are few readily available alternatives to captan. The available alternatives are usually most effective when used in combination with other fungicides.

Table 1. Estimated acreage and value of cotton, peanuts, rice, and soybeans planted in the United States in 1979. 1/

Commodity	Acres	Value
Cotton	13,900,000	5,029,194,000
Peanuts	1,549,000	821,313,000
Rice	3,070,000	1,325,670,000
Soybeans	71,700,000	13,875,465,000

1/ Source: Acreage, Crop Reporting Board, Economics, Statistics, and Cooperatives Service, USDA, Washington, DC (released June, 1979).

Table 2. Principal captan-containing products used on soybeans.

Product 1/	% Captan (a.i.)	Formulation 2/	Package size	Cost 3/ (lb, gal form.)	Labelled rate (unit/unit)
Captan-Moly (Stauffer)	25.0	D	20 lb	1.29	4 oz/bu
Captan 4F (Stauffer)	38.5	F	5 gal	15.50	1-1/2-2-1/2 fl oz/cwt
Captan 75W (Stauffer)	75.0	WP	50 lb	2.55	1 oz/bu
Captan 80W (Stauffer)	80.0	WP	50 lb	2.68	1 oz/bu
Captan-Methoxyclor 65-10 (Stauffer)	65.0	WP	50 lb	3.02	1-1/5 oz/bu
Captan-Methoxychlor 75-2 (Stauffer)	75.0	WP	50 lb	2.67	1 oz/bu
Orthocide 4F SP (Chevron)	37.2	F	5 gal	18.00	2-1/2 fl oz/cwt
Orthocide 75 SP (Chevron)	75.0	WP	50 lb	3.13	1-2/3 oz/cwt
Isotox Seed Treater (F) (Chevron)	25.0	D	1 lb	7.35	2 oz/cwt
Orthocide Methoxyclor 75-3 SP (Chevron)	75.0	WP	50 lb	3.39	1-2/3 oz/cwt
Orthocide Methoxyclor 75-5 SP (Chevron)	75.0	WP	50 lb	3.47	1-2/3 oz/cwt
Soil Treater 3X (Chevron)	30.0	D	20 lb	2.54	3 oz/bu
Soybean Seed Protectant (MO) (Chevron)	25.0	D	20 lb	3.55	7 oz/cwt

1/ Product manufacturers listed are Stauffer Chemical Company, Westport, Connecticut, and the Chevron Chemical Company, Richmond, California.

2/ D = dust; F = flowable; WP = wettable powder.

3/ Cost figures were provided by company representatives of the respective companies on May 13, 1980, and are subject to change and local variation.

Table 3. Registered fungicide alternatives for captan for use on soybeans.

Disease	Fungicides(s) 1/
Seedling disease complex	Busan
	Carboxin
	Chloranil
	Chloroneb
	HCB (Hexachlorobenzene)
	HCB + Maneb
	Maneb
	Maneb + Zinc
	PCNB + ETMT (Terrazole)
	Thiram
	Zineb

1/ Common names used where possible.

Selected References

1. Caldwell, B. E. (Ed). 1973. Soybeans: Improvement, Production, and Uses. American Society of Agronomy, Madison, Wisconsin. 681 pp.

2. Dickson, J. G 1956. Diseases of Field Crops. McGraw Hill Book Company, New York. 517 pp.

3. Kipps, M. Smith. 1970. Production of Field Crops. McGraw Hill Book Company, New York. 790 pp.

4. Martin, J. H. and W. H. Leonard. 1967. Principles of Field Crop Production. The MacMillan Company, New York. 1044 pp.

5. Sinclair, J. B. and M. C. Shurtleff (Eds). 1975. Compendium of Soybean Diseases. American Phytopathological Society, St. Paul, Minnesota. 69 pp.

PEANUTS

I. Commodity Information

Peanuts are an important source of human food and are also used as a livestock feed. Primarily grown in the southern portion of the United States, peanuts are a major cash crop in the production areas. These areas include states along the Atlantic Ocean southward from Virginia and states bordering the Gulf of Mexico, including the Oklahoma-Arkansas-Tennessee area. In 1979 about 1.5 million acres were planted. Production from this acreage was valued at 0.8 million dollars (Table 1). Commercial production of peanuts requires a high level of technology and mechanization.

II. Pest Information

Peanut diseases that are controlled by Captan are seed and seedling diseases. The incitants of these diseases are commonly present in the soil wherever peanuts are grown and may be on or in the planting soil. When a fungicide is not used for controlling these diseases, planted seed may decay, or seedlings which develop may be reduced in vigor or killed by seedling diseases. Reduced seedling vigor and/or stands may result in reduced yields, depending on the severity of the diseases. Low vigor and reduced seedling stands can result in the inefficient utilization of herbicides and fertilizers. Overall production costs can be increased by additional weed control costs or even the cost of replanting. Changes in management practices and delayed crop maturity and harvest can add to production costs.

Several fungi may be associated with seed and seedling diseases. These fungi include species of _Aspergillus_, _Diplodia_, _Fusarium_, _Macrophomina_, _Penicillium_, _Pythium_, _Rhizoctonia_, _Rhizopus_, and _Sclerotium_. Other fungi, and bacteria, can also be involved in the seed and seedling disease complex.

III. Captan Use

a. Geographic areas of use

Captan is used throughout the peanut growing areas of the United States to help control seed and seedling diseases.

b. Acres or units treated

Information is not available to use as a reliable basis for making an estimate of usage.

c. Pesticide product

Product information is given in Table 2.

d. Application techniques

All of the captan containing products listed in Table 2 are applied to planting seed. The Soybean Seed Protectant formulation is applied as a planter box treatment by growers. The other products are applied by commercial seed treaters as slurry applications. Labelled use rates are given in Table 2.

No special equipment is involved in the use of captan as a planter box treatment, measured quantities of dust formulations being added to the seed in a planter box or pre-mixed with the seed in some manner. Commercial seed treating equipment simply

mixes a known quantity of captan with a known quantity of seed in a repeating, continuing operation. Protective equipment and/or clothing are not usually used by workers during the planting operation. Information is not available on the use of protective equipment and/or clothing by workers in commercial seed treating operations.

e. Field operations after fungicide application

There are no field operations related to post-pesticide treatment activities.

IV. Exposure Hazards

a. General public

The registered uses of captan as a seed treatment for peanuts does not result in a exposure hazard to the general public.

b. Workers in commercial seed treating operations

Persons who work in commercial seed treating operations may be exposed to hazards related to inhalation of the fungicide or skin contact with it. All of the products used on peanuts are applied as slurry treatments, and therefore, exposure is considered minimal.

c. Field applicators

Commercially treated seed present little hazard to workers involved in the planting operation. Some hazard to workers from dust particles exists when planter box treatments are

transferred in the field from the fungicide containers to the planter box or mixing container. These hazards are minimized or eliminated when recommended procedures are followed.

V. Role of Captan

Captan is used in every peanut producing state as a fungicide seed treatment to help control seed and seedling diseases of peanut. It is compatible with several other fungicides and several insecticides, and is used in combination with them in order to protect seed against insects as well as against a broad spectrum of microorganisms. One of the principal seed fungicides used in the United States, captan is relatively inexpensive and competitive in this respect with alternative fungicides.

Breeders who have worked with various aspects of seed and seedling vigor have improved this character in peanut plants. Seed and seedling health may also be improved by following, wherever possible, such basic practices as crop rotation, sanitation, and recommended crop management. Nevertheless, the fundamental factors--soil, seed, microorganisms, climate--involved in seed and seedling diseases are of a nature such that it appears that in most planting situations a fungicide, such as captan, will be needed.

VI. Alternative Registered Fungicides

a. Planter box treatments

There are few viable alternatives to captan as a planter box treatment. Many of the commonly used formulations

employ captan alone or in combination with other fungicides. Other widely used products contain PCNB which has an uncertain future because it is now in the RPAR procedure. Thiram is a third material which has some use as a planter box fungicide.

b. Seed treatments

Registered fungicides which may be used on peanuts instead of captan are listed in Table 3. Although registered not all of the products listed are available. Marketing realities may result in a limited number of fungicides being available to growers in a specific area. As noted above, PCNB containing products are not viable alternatives because of the uncertainty related to their involvement in the RPAR procedure. Nevertheless, several alternatives to captan are registered. These alternatives are generally most effective when used in combination with other fungicides.

VII. Summary

Captan is used in all peanut growing states as a seed treatment. The fungicide is used as a planter box treatment and as a seed processor-applied slurry treatment. The several registered alternatives to captan are most effective when used in combination with other fungicides.

Table 1. Estimated acreage and value of cotton, peanuts rice, and soybeans planted in the United States in 1979. 1/

Commodity	Acres	Value
Cotton	13,900,000	5,029,194,000
Peanuts	1,549,000	821,313,000
Rice	3,070,000	1,325,670,000
Soybeans	71,700,000	13,875,456,000

1/ Source: Acreage, Crop Reporting Board, Economics, Statistics, and Cooperatives Service, USDA, Washington, DC (released June 28, 1979).

Table 2. Principal captan-containing products used on peanuts.

Product 1/	% Captan (a.i.)	Formulation 2/	Package size	Cost 3/ (lb, gal form.)	Labelled rate (unit/unit)
Captan 4F (Stauffer)	38.5	F	5 gal	15.50	6 fl oz/cwt
Captan 25 Seed Protectant (Stauffer)	25.0	D	10 lb	1.28	4-6 fl oz/cwt
Captan 75 (Stauffer)	75.0	WP	50 lb	2.55	4 oz/cwt
Captan 80 (Stauffer)	80.0	WP	50 lb	2.68	3 3/4 oz/cwt
Captan-Thiram 43-43 (Stauffer)	43.0	D	50 lb	3.13	4-4 1/2 oz/cwt
Orthocide 4F SP (Chevron)	37.2	F	5 gal	18.00	6 fl oz/cwt
Soybean Seed Protectant (Chevron)	25.0	D	20 lb	3.55	4-6 oz/cwt

1/ Product manufacturers listed are Stauffer Chemical Company, Westport, Connecticut, and the Chevron Chemical Company, Richmond, California.

2/ D = dust; F = flowable; WP = wettable powder.

3/ Cost figures were provided by company representatives of the respective companies on May 13, 1980, and are subject to change and local variation.

Table 3. Registered fungicide alternatives for captan for use on peanuts.

Disease	Fungicide(s) 1/
Seedling disease complex	Captafol
	Captafol + Dichloran
	Captafol + Thiram
	Carboxin
	Carboxin + Captafol
	Dichloran
	PCNB + ETMT (Terrazole)
	Thiram

1/ Common names used where possible.

Selected References

1. Dickson, J. G. 1956. Diseases of Field Crops. MaGraw Hill Book Company, New York. 517 pp.

2. Horne, C. W. 1974. Peanut Disease Atlas. Texas Agric. Exten. Ser., College Station, 16 pp.

3. Kipps, M. Smith. 1970. Production of Field Crops. McGraw Hill Book Company, New York. 790 pp.

4. Martin, J. H. and W. H. Leonard. 1967. Principles of Field Crop Production. The MacMillan Company, New York. 1044 pp.

VEGETABLES (FOLIAR SPRAYS)

I. Commodity Information

Vegetables are grown commercially in all 50 states on 3 1/2 million acres. They are grown somewhere in the U.S. every month of the year. Disease control in vegetable crops is truly integrated, with widespread use of: resistant varieties, certification programs to insure disease-free propagation material, crop rotation and other cultural controls, and the use of fungicides, bactericides, nematicides and other insecticides for disease control. Factors which limit the use of non-chemical disease control are: quality or processing characteristics which limit the use of resistant varieties and the intensive nature of vegetable crop production particularly in urban market garden areas and winter vegetable crop production. To control many diseases by crop rotation, a given crop would need to be absent from a specific area for more than 3 years. High land taxes, inflationary production costs, specialized equipment, and limited land suitable for vegetable crop production often prohibit obtaining enough land to establish the crop rotation needed for disease control.

Another factor which necessitates the use of pesticides in vegetable crop production is the high demand for quality, blemish-free produce. Thus, both field and post-harvest disease control is often required.

At present, there are no known biological control agents for these specific foliar vegetable diseases.

II. Foliar Uses of Captan

a. Areas of use

Captan has been recommended in 26 states for the control of 38 diseases on 21 different vegetable crops. The use of captan for vegetable disease control is more effective than no fungicide at all, but not as effective as many of the recommended alternative fungicides (Tables 1-14).

Beans, beets, carrots, celery, corn, cucurbits, eggplant, lettuce, onions, peppers, potatoes and tomato producers would not be seriously affected by loss of captan as a foliar spray. Two captan use sites could be economically affected. These are: 1) greenhouse-grown rhubarb could be affected since captan is an effective control measure for Botrytis leaf rot. The only other effective registered fungicide is DCNB (Botran) for the control of Botrytis leaf rot, leaf stalk spot and anthracnose in several states. Greenhouse rhubarb production is limited to several restricted areas in Macomb County, Michigan. The production of glasshouse rhubarb has decreased dramatically in recent years and the usage of captan is difficult to estimate and is considered to be minor compared to other uses of captan. 2) Control of downy mildew of spinach. Captan was shown to be more effective than zineb, a registered alternative fungicide (6). Maneb, however, was demonstrated to be more effective than both captan and zineb for

control of anthracnose (3). Alternative controls are the use of downy mildew-resistant varieties and many acceptable resistant varieties are available. Tomato growers in Florida also use captan in combination with copper for bacterial spot control. However, state extension plant pathologists do not recommend this practice nor can published research data be located to indicate its effectiveness. Data does show that copper and maneb or mancozeb are more effective than copper alone.

b. Amounts used

The acres of spinach and the acres of greenhouse-produced rhubarb are unknown. Production of greenhouse rhubarb is restricted to Macomb County, Michigan. Captan has already been replaced by more effective compounds in vegetable foliar spray programs and therefore the total amount used is probably not very great.

c. Formulations of captan

Formulations of captan registered and sold for foliar use on vegetables are listed in Table 15. These formulations include wettable powders, dusts and flowables. Orthocide 50 Wettable (Chevron) is the only formulation which has a label for foliar use on spinach. There is no label published (1,9) which allows use of captan as a foliar spray on greenhouse produced rhubarb even though it is on the federal register (12).

d. Application equipment, techniques and rates

Foliar applications of captan are applied to vegetables using

of [illegible] (3). [illegible]

[illegible] [illegible]

are available. [illegible]

[illegible] ion with [illegible]

[illegible] ion plant patho[illegible]

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effective than copper s[illegible]

[illegible] of copper [illegible]

[illegible] unknown. [illegible]

[illegible] to Macomb County, Michigan [illegible]

[illegible] by more effective compounds [illegible]

[illegible] therefore [illegible]

[illegible] ions of copper

[illegible] mulations of copper [illegible]

[illegible] listed in Table [illegible]. [illegible]

[illegible] dusts and flowable [illegible]

[illegible] the only formulation which [illegible]

The [illegible] label published [illegible]

foliar spray on [illegible]

[illegible] (12).

ground-type spraying equipment. From 6-20 acres could be sprayed per hour depending upon the calibration of the spray equipment used and the crop involved.

The recommended rates for captan fungicides applied as foliar sprays on vegetables depend both on the crop and particular disease involved as well as the specific formulation of captan used (Table 16). Captan products manufactured by Chevron and Stauffer are established at standard rates applicable for disease control throughout the United States. The Ortho (9) and Stauffer (1) captan wettable powder formulations are mixed at the rate of "x" lbs active ingredient per 100 gallons of water then applied as "x" gallons spray per acre according to the specific crop. Ortho dusts are applied at "x" lbs active ingredient per acre according to the specific crop.

III. Exposure Hazards

The extent of personal exposure to captan during the weighing, filling and mixing of the fungicide as well as applying the chemical as a foliar spray on vegetables is not presently known. Since it is common for growers to tank mix highly toxic insecticides with captan, protective clothing is normally worn throughout the spray operation.

Three possible forms of exposure to captan dust, powder or spray mist are: inhalation, dermal contact and oral ingestion. Inhalation of captan dusts and powder can occur upon emptying into mixing tanks. The mere opening and closing of containers and product bags can create particulate dust which can also be inhaled. Dermal contact can occur during the mixing and spraying procedures themselves. Oral ingestion could possibly occur due to intake of powder, dust or spray into the mouth.

IV. Information on Other Registered Fungicides Used as Foliar Sprays on Vegetables

a. Foliar fungicides for vegetables.

The states recommending captan for control of foliar diseases of vegetables such as anthracnose, scab, downy mildew, powdery mildew, early blight and late blight have several alternatives (Tables 1-14). Vegetable producers would not be seriously limited in choice of fungicides if captan were lost. Maneb-zineb (EBDC´s) with chlorothalonil (Bravo) and captafol (Difolatan) are the most widely recommended alternatives.

Efficacy of captan as opposed to alternative fungicides is demonstrated in the annual publications of <u>Fungicide and Nematicide Test Results</u> (published by the American Phytopathological Society) where data from comparative fungicide trials are compared. The majority of tests comparing captan with other fungicides occurred in the 1950´s and 1960´s before widespread testing of

possible forms of [illegible]

inhalation, dermal [illegible] and oral ingestion. Inhalation of [illegible] and powder can occur when emptying into mixing [illegible] and blowing [illegible] containers [illegible] and product here can occur [illegible] ate dust which can also be inhaled. Dermal contact [illegible] the mixing and spraying procedures themselves. [illegible] occur due to intake of powder, [illegible]

Formation on Other Registered Fungicides Used [illegible]

Vegetables

Foliar Fungicides for Vegetables.

[illegible] states recommending [illegible] for control of foliar diseases [illegible] tables such as [illegible], [illegible] downy mildew, [illegible] early blight and late blight [illegible] (Table 1-18). Vegetable producers would not be [illegible] choice of fungicides if captan were lost. [illegible] chlorothalonil (Bravo) and captafol (Difolatan), are [illegible]

Efficacy of captan as opposed to alternative fungicides [illegible] contrasted in the annual publications of Fungicide and Nematicide Results (published by the American Phytopathological Society) [illegible] from comparative [illegible] trials [illegible]. The [illegible] tests comparing captan with other fungicides conducted [illegible] widespread testing of

chlorothalonil and captafol. Therefore, most tests were comparisons of captan with EBDC fungicides. In more recent tests chlorothalonil and captafol were shown to be as effective or more effective than the EBDC fungicides. The exclusion of captan from more recent trials perhaps indicates that researchers consider it less effective to the degree that it is not worthy of comparison. Maneb was generally rated as more effective in disease control than captan and the most effective of all the alternative fungicides in the published tests available. Efficacy data is condensed in Tables 1-14. Some examples are control of late blight of potato with captan which resulted in 3% tuber rot and a yield of 633 bu/A whereas with maneb there was a 2.7% tuber rot and a yield of 680 bu/A as compared to the control, with 6% tuber rot and yield of 532 bu/A (11). Captan, however, caused a reduction in yield and was not suggested for grower use.

b. Impact of captan cancellation

Gray mold or Botrytis leaf rot of rhubarb occurs on hothouse forced rhubarb, rarely on the outdoor crop (7,8). Weekly sprays of captan have been recommended for control of this disease (5,8). Efficacy of captan as opposed to alternative fungicides showed that captan was given the highest rating both for disease control of gray mold, plant safety and yield in one test (8), and maneb gave better but not significantly better control than captan in another test (7). In addition, gray mold can also be a serious problem during fresh market storage and transit of rhubarb (7,10).

Anthracnose can be a problem on rhubarb both in the field and

[illegible] and control. [illegible]

[illegible] treated with [illegible] fungicides. [illegible]

[illegible] ions, and captan [illegible]

[illegible] than the [illegible]

[illegible] trials [illegible]

effective [illegible]

[illegible] rated [illegible]

and the most effective of all [illegible]

p of that tests available. [illegible]

s 1-14. Some examples [illegible]

[illegible] which resulted in [illegible]

es with [illegible] there was a 2.75 [illegible]

compared to the [illegible]

). Captan, however, caused a [illegible]

[illegible] for [illegible] use.

[illegible] of captan [illegible]

[illegible] mold or Botrytis [illegible]

[illegible] ubarb, rarely in the outdoor crop [illegible]

[illegible] n have been recommended for control of this disease [illegible]

[illegible] of captan as opposed to alternative [illegible]

[illegible] the highest rating both for disease [illegible]

[illegible] d yield in one test [illegible]

[illegible] tly better control [illegible]

[illegible] ition, gray mold [illegible] s a serious problem

[illegible] ate ago and [illegible] t of rhubarb (7,10).

[illegible] th [illegible] the 11-19 and

during storage and transit (10). There are no published data rating the efficacy of captan. Kentucky is the only state recommending captan for control of anthracnose and there are no recommended alternative fungicides.

Rhubarb production centers are located in Washington, Michigan, California, Oregon, and New York (10). While rhubarb for the fresh market is not a major commodity, it is a leading commodity in such places as Macomb County, Michigan and constitutes a high value cash crop (10). Removal of captan could result in economic losses in rhubarb because Botrytis leaf rot is a constant problem and threat in rhubarb production. However, DCNA-Botran is considered to be highly effective. Another fungicide which, if registered, would be highly effective is chlorothalonil. Perhaps this fungicide could be registered via the IR-4 program.

V. Summary

In summary, the loss of captan as foliar fungicide in commercial vegetable crop production would not be significant except where specified above. Growers are already using more effective compounds and basically are no longer using captan in foliar spray programs.

Tables 1-14. Summary of recommended foliar uses of captan on vegetables by state and its alternatives

Table 1.

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
BEANS (field, lima, pole,wax)				
anthracnose	Arizona Iowa Louisiana Mississippi Nebraska Texas	maneb, zineb, fixed copper, maneb-zinc, benomyl, chlorothalonil		
downy mildew	Louisiana Mississippi Nebraska	maneb-zinc, maneb, fixed copper, chlorothalonil, benomyl	maneb more effective than captan	Fungicide and Nematicide Tests - 1953, 1954, 1955 1956
rust	Louisiana Wyoming	chlorothalonil, maneb-zinc, sulfur, zineb, copper oleate, copper sulfate, nabam		
gray mold (not registered)	Idaho Oregon Washington	dichloran, chlorothalonil		

Table 2

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
BEETS (garden and sugar)				
Alternaria leaf spot	Massachusetts Mississippi Nebraska Texas	fixed copper, benomyl, chlorothalonil, anilazine, folpet, maneb, maneb-zinc, zineb, thiram	Note: captan is generally ineffective on *Alternaria* sp. incited diseases	
Cercospora leaf spot	Arizona Massachusetts Mississippi Nebraska Texas	zineb, fixed copper, benomyl, chlorothalonil, anilazine, folpet, maneb maneb-zinc, thiram	benomyl more effective than captan	Fungicide and Nematicide Tests - 1978, Report 112.
Septoria leaf spot	Illinois Massachusetts Mississippi Nebraska Texas	fixed copper, benomyl, chlorothalonil, anilazine, folpet, maneb, maneb-zinc, zineb, thiram		

Table 3

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
CANTALOUPES, CUCUMBERS, MUSKMELON, HONEYDEW MELON, PUMPKINS, SQUASH (summer and winter) WATERMELONS				
Angular leaf spot	Alabama	thiram, copper, maneb, ziram, maneb-zinc, captafol,	captan is not effective for control of bacterial diseases	
	Iowa Kentucky Mississippi New Hampshire Oklahoma Texas Vermont	folpet, chlorothalonil, benomy, fixed copper, zineb, polyram, anilazine		
Anthracnose	Alabama Connecticut Illinois Iowa Michigan New Hampshire North Dakota Oklahoma Rhode Island Virginia	benomyl, chlorothalonil, captafol, maneb-zinc, anilazine, maneb, zineb, folpet, thiram, ziram, Bordeaux mixture, copper	maneb more effective than captan	Fungicide and Nematicide Tests - 1954, 1955, 1956, 1957, 1959
downy mildew	Alabama Connecticut Illinois Iowa North Dakota Rhode Island	chlorothalonil, polyram folpet, maneb-zinc, zineb, maneb, captafol anilazine, thiram, ziram	maneb more effective than captan	Fungicide and Nematicide Tests - 1954, 1955, 1956, 1957, 1959, 1961

	Virginia	
Scab	Alabama Connecticut Illinois New Hampshire Rhode Island Vermont	maneb, zineb, maneb-zinc, folpet, chlorothalonil, captafol, fixed copper

Table 4

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
CARROTS				
Alternaria blight	Mississippi Nebraska Texas Virginia	maneb, maneb-zinc, zineb, chlorothalonil, fixed copper, benomyl, anilazine, folpet	Note: captan is not effective on diseases incited by <u>Alternaria</u> sp.	
Cercospora blight	Illinois Iowa Mississippi Nebraska Texas Virginia	maneb, maneb-zinc, zineb, chlorothalonil, fixed copper, benomyl, anilazine, folpet		
Septoria leaf spot	Mississippi Nebraska Texas Virginia	chlorothalonil, anilazine, folpet, maneb, maneb-zinc, zineb, fixed copper		

[illegible]

Table 5

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
CELERY				
Late blight (Septoria)	Michigan Mississippi Texas	ferbam, chlorothalonil, benomyl, anilazine, maneb, maneb-zinc, fixed copper, folpet	anilazine, maneb more effective than captan	Fungicide and Nematicide Tests - 1958
Pink rot (Sclerotinia)	Michigan Mississippi	ferbam, chlorothalonil, anilazine, benomyl, maneb, maneb-zinc, fixed copper	benomyl is considered to be the most effective control	

[illegible]

[illegible]

[illegible]

[illegible]

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Table 6

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
CORN				
Helminthosporium leaf blight	Iowa Nebraska Mississippi Texas	zineb, carboxin-thiram, thiram, benomyl, chlorothalonil, anilazine, folpet, maneb, maneb-zinc, fixed copper	maneb more effective than captan	Fungicide and Nematicide Tests - 1983, 1985

Table 7

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
EGGPLANT				
Early blight (Alternaria)	Georgia Iowa Kentucky Mississippi Nebraska Oklahoma	maneb, zineb, maneb-zinc, thiram, fixed copper, benomyl, chlorothalonil, anilazine, folpet		
Anthracnose	Illinois Iowa Kentucky Mississippi Nebraska Oklahoma	thiram, maneb, zineb fixed copper, benomyl, chlorothalonil, anilazine, folpet, maneb-zinc		
Phomopsis blight	Illinois Kentucky Mississippi Oklahoma	thiram, maneb, zineb, fixed copper, benomyl, chlorothalonil, anilazine, folpet maneb-zinc		
Fruit rot	Oklahoma	maneb, zineb		

Table 8

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
LETTUCE				
Downy mildew	Alabama Nebraska Vermont	maneb, zineb, folpet, benomyl, chlorothalonil, anilazine, maneb-zinc, fixed copper	maneb more effective than captan	Fungicide and Nematicide Tests - 1956

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]

[illegible]

Table 9

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
ONIONS (green and bulb)				
downy mildew	Arizona Louisiana Mississippi Nebraska	anilazine, maneb, maneb-zinc, captafol, chlorothalonil, fixed copper benomyl, folpet, zineb	maneb more effective than captan	Fungicide and Nematicide Tests - 1953
purple blotch	Illinois Iowa Mississippi Nebraska	thiram, captafol, anilazine, chlorothalonil, maneb-zinc, zineb, fixed copper, benomyl, folpet, maneb	captafol more effective than captan	Fungicide and Nematicide Tests - 1977, Report 132

Table 10

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
PEPPERS PIMENTOS				
anthracnose	Connecticut Illinois Iowa Kansas Kentucky Louisiana Mississippi Nebraska North Carolina Oklahoma Rhode Island	thiram, maneb, zineb, fixed copper, benomyl, chlorothalonil, anilazine, folpet, maneb-zinc	maneb and zineb more effective than captan	Fungicide and Nematicide Tests - 1957
Cercospora leaf spot and stem-end rot	Kentucky Louisiana Mississippi Nebraska North Carolina Oklahoma Texas	zineb, maneb, maneb-zinc, fixed copper, benomyl, chlorothalonil, anilazine, folpet		

Table 11

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
RHUBARB (greenhouse)				
leaf rot (Botrytis cinerea)	Idaho Kansas Kentucky	dichloran, maneb	captan more effective than maneb	Fungicide and Nematicide Tests - 1960
leaf stalk spot (not registered)	Illinois Iowa Kentucky	dichloran		
anthracnose (not registered)	Kentucky	none		

Table 12

Commodithy/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
SPINACH				
downy mildew	Alabama Kansas Mississippi Nebraska North Carolina Vermont Virginia	zineb, maneb, fixed copper	captan more effective than zineb	Fungicide and Nematicide Tests - 1953
anthracnose seedborne leaf spot (not registered)	Illinois Iowa	thiram	maneb more effective than captan	Fungicide and Nematicide Tests - 1953
white rust (not registered)	North Carolina	maneb, zineb		

Table 13

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
POTATOES				
early blight late blight	Mississippi Nebraska North Dakota Vermont Virginia	chlorothalonil, captafol, fixed copper, maneb-zinc, benomyl, folpet, zineb, anilazine	zineb more effective than captan	Fungicide and Nematicide Tests - 1953
			maneb more effective than captan	Fungicide and Nematicide Tests - 1953, 1958
			captafol more effective than captan	Fungicide and Nematicide Tests - 1971, 1977

Table 14

Commodity/Crop Disease	States recommending captan	State recommendations/ alternatives	Efficacy of alternatives in published tests	Reference
TOMATOES (field and greenhouse)				
anthracnose	Alabama Illinois Iowa Mississippi Nebraska Pennsylvania Texas Virginia	folpet, chlorothalonil, zineb, maneb-zinc, maneb, captafol, anilazine, polyram, thiram, fixed copper, benomyl, tribasic copper sulfate	maneb more effective than captan	Fungicide and Nematicide Tests - 1954, 1955, 1956, 1958
early blight	Alabama Illinois Iowa North Dakota Pennsylvania Virginia Wyoming	chlorothalonil, zineb, maneb-zinc, maneb, captafol, anilazine, polyram, thiram, tribasic copper sulfate, fixed copper, amoban	maneb more effective than captan	Fungicide and Nematicide Tests - 1953, 1954, 1955, 1956, 1957, 1958
late blight	Alabama North Dakota Virginia Wyoming	chlorothalonil, zineb, maneb-zinc, maneb, captafol, anilazine, polyram, fixed copper, amoban	maneb more effective than captan	Fungicide and Nematicide Tests - 1953, 1957
gray leaf spot (Stemphylium)	Alabama Virginia	chlorothalonil, zineb, maneb-zinc, maneb, captafol, anilazine, polyram, benomyl	maneb more effective than captan	Fungicide and Nematicide Tests - 1958
Septoria leaf spot	Alabama Illinois	zineb, maneb-zinc, maneb, anilazine, thiram, chloro-	maneb more effective than captan	Fungicide and Nematicide Tests -

VEGETABLES (FOLIAR SPRAYS)		245	1956
Iowa	thalonil, captafol		
Louisiana	fixed copper, folpet		
Mississippi	benomyl		
Nebraska			
Virginia			

Table 15. Captan fungicides (1,9) used as a foliar spray on vegetables.

Product	Formulation	% Captan a.i.
Orthocide 80 Wettable (Chevron)	WP	80.0
Orthocide 50 Wettable (Chevron)	WP	50.0
Orthocide 4 Flowable (Chevron)	F	38.0
Orthocide 10 Dust (Chevron)	D	10.0
Orthocide 5 Dust (Chevron)	D	5.0
Orthocide 7.5 Dust (Chevron)	D	7.1
Captan 80 WP (Stauffer) (East of Rockies)	WP	80.0
Captan 80 WP (Stauffer) (West of Rockies)	WP	80.0
Captan 50 WP (Stauffer) (East of Rockies)	WP	50.0
Captan 50 WP (Stauffer) (West of Rockies)	WP	50.0
Captan 4 Flowable (Stauffer) (West of Rockies)	F	38.5

WP = wettable powder

F = flowable

D = dust

Table 16. Registered and labelled (1,9,12) application rates of captan applied as a foliar spray to vegetable crops.

Commodity/Crop Disease	Application Rates WP lbs a.i./100 gal	 lbs a.i./acre	 D lbs a.i./acre
BEANS (field, lima, pole, wax) anthracnose, downy mildew, rust	0.50	---1/	2-3
BEETS (garden, sugar) Alternaria, Cercospora, Septoria leaf spots	1.00	---	---2/
CURCURBITS (cantaloupes, cucumbers, muskmelon, honeydew melon, pumpkins, squash (winter and summer), watermelons) angular leaf spot, anthracnose, downy mildew, scab	1.0-1.5	2.0	1.125-3.80
CARROTS Alternaria, Cercospora leaf blights, Septoria leaf spot	1.00	2.0	2.25-3.00
CELERY Septoria late blight, Sclerotinia pink rot	1.00	2.0	---
CORN Helminthosporium leaf blight	0.75	---	6.00
EGGPLANT early blight (Alternaria), anthracnose, Phomopsis blight, fruit rot	1.00	3.0	---
LETTUCE downy mildew	1.00	2.0	2.50
ONIONS (green and bulb) downy mildew, purple blotch	1.00	1.5	---
PEPPERS, PIMENTOS anthracnose, Cercospora leaf spot and stem-end rot	1.50	3.0	---

RHUBARB (greenhouse)			
Botrytis leaf rot	1.00	---	---
SPINACH			
downy mildew	1.00	---	---
POTATOES			
early blight, late blight	2.0-4.0	3.0-6.0	1.75-3.00
TOMATOES (field and greenhouse)			
anthracnose, early blight, late blight, Stemphylium gray leaf spot, Septoria leaf spot	1.0-2.0	2.0-3.0	2.00-5.00

1/ Information not available to make calculation.

2/ Not used on that specific crop.

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VEGETABLES

I. Commodity Information

Vegetables are grown commercially in all 50 states on 3 1/2 million acres and are growing somewhere in the U.S. every month of the year. Healthy vigorous seed that will give rise to sturdy plants is an economic necessity to result in uniform numbers of plants that will remain healthy until harvested 35-120 days after planting. Also mechanical harvesting techniques now require uniform emergence and spacing for maximum efficiency. Large seeded vegetables such as beans, peas, sweet corn and squash are often planted very early in cold wet soils making them prone to attack by fungus pathogens in the soil. Until safe economic chemical seed treatments were developed in the 1950's, early planting was risky and seeds were often severely damaged or destroyed by soil fungi and bacteria. Peas, snap beans, dry beans, and sweet corn adequately protected with captan, dexon, or thiram are now planted on 2,865,000 acres with growers being assured of good protection against seed rot and pre-emergence damping-off.

Potato tubers cut into 2-4 sections for planting offer extensive tissue exposed to soil-borne pathogens. Captan or maneb dust (8-10%) have demonstrated excellent protection against Fusarium, Rhizoctonia and Streptomyces fungus organisms when lightly dusted over the fresh cut pieces. An estimated 383,000 acres of potatoes are planted with captan treated seed, or an average of about 28% of the United States acreage. In the northeastern states mancozeb dusts are more commonly used instead

, es are grown commercially [illegible]

are annually [illegible] in the U.S. [illegible]

vigorous seed that will [illegible]

necessity [illegible] result [illegible] uniform [illegible]

healthy until harvested [illegible]

harvesting each crop [illegible]

for maximum efficiency. [illegible]

corn and squash [illegible]

ing them prone to attack [illegible]

e economic chemical [illegible]

early planting was risky [illegible] severely decayed

troyed by soil fungi and bacteria. [illegible]

corn adequately protected with captan, [illegible]

on 2,865,000 acres [illegible] growers [illegible]

against seed rot and pre-emergence damping-[illegible]

ato tubers cut into 2-4 sections [illegible] planting [illegible]

to soil-borne pathogen. [illegible]

ated excellent potential [illegible]

ungus [illegible] when lightly [illegible]

381,000 acres of potatoes are planted. [illegible]

an average of about 38% of the United States acreage.

s mancozeb [illegible] are more commonly used [illegible]

of captan and account for treatment of about 12% additional seed potatoes.

Until the early fifties many farmers had to treat their own seed to obtain this needed protection, however, with the development of captan with its very low skin irritant properties, freedom from phytotoxicity, and ability to ensure good stands of vegetables, seedsmen came to adopt this practice to protect their seeds and thus made their product well accepted. Today a high (60%-90%) percentage of sweet corn, bean and pea seed ofered for sale has been fungicide treated by the seedsmen (Table 1). This practice permits earlier planting in cold wet soils with the assurance that seeds will not rot but will produce sturdy sprouts and plants. In some instances surface treatments reduce fungus pathogens that may be on the seed coat, however, the main objective of captan seed treatment is to ensure protection against seed rot caused by soil fungi.

II. Pest Information

The invasion of the germinating seed before emergence by various fungi results in injury called seed decay or pre-emergence damping-off in which the seed or seedling may be completely destroyed. Frequently, however, only a portion of the seed is invaded and the seedling emerges in a weakened condition. The organisms capable of causing seed decay are numerous including Pythium, Rhizoctonia and Fusarium. For the most part, these fungi live on decaying organic matter in the soil and affect plants only during the pre-emergence seedling stage. Some of these organisms are more aggresssive than others and some crops are more susceptible to certain organisms than others. Large vegetable seeds

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during the pre-emergence seedling stage. Some of these

aggressive than others

vegetable crops

such as sweet corn, peas and beans, often planted in cold wet soils are especially prone to attack by one or more of these fungi. The organic matter content of the soil influences the growth rate of the fungi, the higher the O.M. the more favorable for growth. The soil pH also affects these species in various ways. An acid soil favors Rhizoctonia, while a neutral or alkaline soil favors Pythium. Also Rhizoctonia develops best in relatively dry soils and at higher temperatures, whereas Pythium develops best in wet soils at low temperatures. Such variability in growth habits of these pathogens makes it difficult to predict the need for seed treatment which may actually vary from year to year. Thus a prudent vegetable grower will treat his seed every year to insure adequate germination of the seed and stand of the seedlings.

III. Pesticide (captan) use as a vegetable seed treatment

The literature on the use of fungicides as seed protectants for peas, corn, beets, beans, and soybeans is voluminous (2, 4, 8, 9, 10, 11, 17, 18, 23, 24, 31, 33). The term is to control pathogens on or in the seed by the chemical. Such seed becomes infected or infested sometime before it is harvested. The second implication is the protection of the seed from invasion by soilborne pathogens after planting. Such infection generally occurs under soil environmental conditions that are favorable for growth of the pathogen but generally unfavorable for germination and growth of the seedling. The fungicide must protect the seed until it can germinate and grow.

Contents [illegible]

the D.M. [illegible]

these appeared [illegible]

means of dilution [illegible]

a host in relatively [illegible]

Pythium disease, [illegible]

ity in growth [illegible]

the host for seed growth, and [illegible]

in a dominant degree [illegible]

equal, conclusion [illegible]

cide (contd.) use [illegible]

literature on the use [illegible]

corn, oats, beans, and [illegible]

18, 23, 24, 33, 37. [illegible]

by the chemical. Such [illegible]

before it is [illegible]

of the seed [illegible]

infection generally occurs [illegible]

that are favorable for [illegible]

the germination [illegible] growth of the seedlings. [illegible]

[illegible]

Captan is a wide spectrum fungicide that controls most soilborne and seedborne pathogens especially species of Fusarium, Rhizoctonia, and Pythium. It does not control pathogens that are internal having grown into the embryo (13). The mode of action of captan is not completely understood, however, work has indicated that fungitoxicity is due to the combination of thiophosgene with free sulfhydrol, amino, hydroxyl, and possibly carboxyl groups within fungal tissue. Another possibility is the combining of the trichloromethylthio groups through the free bond of sulfur to certain groups of enzymes, coenzymes or other vital cellular components (21). Other evidence suggests toxicity is due to a blockage of phosphorus metabolism by an intact molecule and not by a decomposition product of captan (28). The probability of resistance developing in target fungi is very unlikely due to multisite activities and to the prolonged period of use since the 1950's without the detection of resistant populations (21).

Captan decomposes fairly rapidly in moist soil probably through action of soil bacteria. After 3-4 days, 50% of the chemical disappears (5). Within 14 days most or all has decomposed. This property is especially important in a seed protectant. Enough chemical must be present to protect the seed from soil pathogens until the seed germinates but then ideally it should disappear. Additionally, captan breaks down rapidly upon exposure to sunlight with 64% degradation after 8 hours exposure to ultraviolet light (34). This is an important trait on seeds with cotyledons that emerge above the soil surface with traces of the fungicide on them. Thus captan breaks down and poses no burden on the environment.

[illegible] is a wide spectrum fungicide [illegible]
the pathogens especially [illegible]
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certain groups [illegible]
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[illegible] in target fungi is [illegible]
the prolonged period [illegible]
of resistant populations (14).

[illegible] decomposes [illegible]
[illegible] bacteria. [illegible]
in 14 days [illegible]
important in [illegible] seed protects [illegible]
protect the seed from soil pathogens until the seed
[illegible] ideally it should [illegible]
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[illegible] plants on [illegible]

a. Sweet corn

One of the first crops to show benefits from captan seed treatment was corn which is often planted in cold wet soils where the seeds are at the mercy of seed rotting fungi for long periods. Numerous papers have reported such benefits (18, 23, 31) over the years. Perusal of the Annual American Phytopathological Society "Fungicide and Nematicide Tests" will show continued reports of the effect of captan in increasing germination of corn by its control of pythiaceous fungi. Sweet corn is grown on 630,950 acres annually with a cash value of $257,837,000. This required 94,630 cwt. of seed, most of which is treated with captan or a captan combination with thiram, thioneb, or carboxin. We estimate 18,000 lbs. a.i. captan are used on this sweet corn (30). See Table 1.

b. Peas

Peas, especially the wrinkled seeded types, are very prone to attack by Pythium spp. in cold wet soils where peas, being a cool season crop, are usually planted. Early work by Natti (24), Wallen (38, 39), Ditman (11), DeZeeuw (10), Haedorn (17), and Richardson (33) demonstrated captan's outstanding ability to protect peas from seed rot and damping-off. Wallen (38) showed that peas grown from captan treated seed were less susceptible to Asscochyta pisi than those grown from untreated seed. A fungistatic substance was found in the treated seedlings by bio-assay, 0.25 ppm captan was found in aboveground parts of such seedlings.

Seedsmen and growers in repeated observations have come

to regard seed treatment of peas a near necessity (Appendix B). We estimate nearly 100% of green edible peas and about 80% of the dry peas planted are now captan treated. Peas are currently grown on 415,790,000 acres with an annual cash value of $128,048,000. This required 2080 cwt. of seed. We estimate 200,000 lbs. a.i. captan are used on this seed. See Table 1.

c. Beans

Beans are similar to peas in their susceptibility to rot when planted in cold wet soils. Pythium and Rhizoctonia spp. attack unprotected seeds to cause seed rot and pre-emergence damping-off. Work by Andersen (1), de Zeeuw (8, 9) Natti (24), Ditman (11) and others demonstrated good stands in the field. Bean seed is fragile and is subject to mechanical injury in handling which increases seed rotting potential. Field beans such as pea beans and red kidney types respond well to treatment when planted in cold wet soils.

Snap beans respond well also to seed treatment, often with an antibiotic added to captan or thiram to protect against surface-borne bacteria. Snap beans are grown on about 400,100 cwt. of seed. We estimate 64,800 lbs. a.i. captan are used. Many with combinations of captan, thiram, or thioneb. Dry beans are grown on about 1,418,700 acres. This requires 1,418,000 cwt. of seed. We estimate 58,000 lbs. a.i. captan are used. This is a total of 122,800 lbs. a.i. captan used on snap and dry beans. Refer to Table 1.

Insecticides are commonly used on bean seed and captan

seed treated: & w, [illegible]

[illegible] nearly [illegible]

plants [illegible]

[illegible] (790,000) acres with [illegible]

[illegible] required 200% [illegible]

[illegible]

seeds are [illegible]

planted in cold wet soil [illegible]

unprotected seeds [illegible]

[illegible]-off. Work by [illegible]

(11) and others demons[illegible]

seed is fragile and is [illegible]

which includes seed [illegible]

pea beans and red kidney [illegible]

planted in cold wet soils.

Lima beans [illegible]

[illegible] to cotton [illegible]

[illegible] snap beans and [illegible]

estimate [illegible] lbs. a.i. [illegible]

[illegible] of cotton, wheat, [illegible]

118,700 acres. This requires [illegible]

78,000 lbs. a.i. cotton [illegible]

lbs. a.i. cotton used [illegible]

acts as a safener for diazinon and Lorsban in addition to its action as a seed protectant against fungi.

d. Miscellaneous vegetables

Many other vegetables benefit from seed treatment with captan, thiram, or dexon. Carrots (29, 37), cucumbers and squash (25), onions (26), cabbage (16), and peppers (20) are known to benefit from captan treatment. Consequently, many commercial seedsmen and some home gardeners use approximately 8,000 lbs. a.i. captan annually. Refer to Table 1.

e. Potato seedpiece treatment

In the mid-seventies work by Cetas (6, 7), Manzer (22), and Rowe (32) showed statistically significant control of seedborne Streptomyces and Rhizoctonia by dusting 10% captan on freshly cut potato seedpieces. Stands were more reliably established by reducing Rhizoctonia stem girdle and lowering scab grade defects on tubers. Maneb and mancozeb were somewhat superior however, because they also controlled Fusarium seedpiece rot. In the far west and south where this disease is of no importance captan established itself as the most popular treatment and has accounted for the very large use figure of 491,000 lbs. a.i. captan. We estimate about 28% of the 1,222,300 acres of potatoes are planted with captan treated seed. Refer to Table 1.

IV. Summary of captan vegetable seed treatment uses

Captan has established itself as the dominant vegetable seed treatment fungicide on peas, dry beans, snap beans, sweet corn, cucumbers, squash, peppers and cabbage. It is widely used also as a potato cut seed dust treatment. A new formulation of captan plus thiabendazol adds effectivenesss against Fusarium and will increase captan use on potato seedpieces. Reference to Table 1 will indicate approximately 348,800 lbs. a.i. captan are used on vegetables with an additional 491,000 lbs. a.i. captan used on potato seedpieces. This totals 839,800 lbs. a.i. captan used on vegetables and potatoes for seed treatment purposes.

Captan a.i. is produced or imported by only three companies: Chevron, Stauffer, and Sol Chem; however, there are presently 136 firms registered with EPA to formulate and offer captan for sale. The majority of captan vegetable seed treatment use involves large seedsmen who grow and treat their seed before sale. These include:

Asgrow, Filer, ID
Brotherton Seeds, Moses Lake, WA
Canners Seed Co., Lewiston, ID
Charter Research, Caldwell, ID
Rogers Bros., Idaho Falls, ID
Illinois Foundation Seed Co., Champaign, IL
Funks Seed Co., Bloomington, IL
Northrup, King & Co., Minneapolis, MN
DeKalb Seedsmen, DeKalb, IL
Louisiana Seed Co., Plainview, TX
Pioneer Hi Bred, Plainview, TX
Joseph Harris Seed Co., Rochester, NY
Seedway, Inc., Hall NY
A. L. Castle, Inc., Morgan Hill, CA
D. V. Burrell Seed Growers, Rocky Ford, CO
Crookham Co., Caldwell, ID

Keystone Seed Co., Hollister, CA
Alf Christianson Seed Co., Mt. Vernon, WA
Ferry Morse Seed Co., Mt. View, WA
Musser Seed Co., Twin Falls, ID

Also some large vegetable processors treat their seed before distributing it to their grower contractors. These include:

Birdseye General Foods, Woodburn, OR
Del Monte Foods, Idaho Falls, ID
Green Giant Foods, Dayton, WA

Captan Seed Treatment Formulations Product	Captan (a.i.) %
Orthocide 75 Seed Protectant Dust	75.0
Orthocide 75 Seed Protectant	75.0
Orthocide 65 Seed Protectant	65.0
Orthocide 4 Flowable Seed Protectant	35.2
Orthocide Potato Seed Treater	15.0
Orthocide Potato Seed Protectant 10	10.0
Orthocide Potato Seed Protectant 5	5.0
Orthocide Streptomycin 7.50-.01 Dust	7.5
Ortho Isotox Seed Treater (F)	25.0
Ortho Isotox Seed Treater (D)	10.0
Orthocide Methoxychlor 75- 5 Seed Protectant	75.0
Orthocide Methoxychlor 75- 3 Seed Protectant	75.0
Orthocide Methoxychlor 65-10 Seed Protectant	65.0
Orthocide Methoxychlor 65- 5 Seed Protectant	65.0
Orthocide Plus	9.5
Stauffer 25 Seed Protectant	25.0

Package sizes vary greatly depending upon the formulator, volume needed by user, formula, etc. The price of product varies greatly with size of package, region, other ingredients, etc.; however, captan a.i. price approximates $3.70 lb. in 1980 according to Stauffer and Chevron Chemical Companies.

V. Application Techniques

Vegetable seed treatments are applied only once and generally by the seed producing company in their facilities where qualified personnel using modern equipment and adequate ventilation and body protective gear do the work. The machinery used is professionally made and provides an accurate dosage mechanism with a minimum of human handling. Practically no seed treatment is done on the farm as it was previous to the late 1950's. The exceptions would be planter box treatments on beans made out of doors in the field, and potato cut seedpiece treatments all done in farm facilities by metering an 8-10% dust over the cwt. potatoes before going to the field.

With seedsmen doing nearly all treating it is more likely that a duly registered chemical is applied properly. Treatments may be affected anytime after seed harvest and before seed is offered for sale or planted. Captan does not deteriorate on the stored seed but certain insecticides, used in combination with captan, do and thus may require that seed treatment be delayed until close to planting.

VI. Application Rates

These vary greatly with formulation and according to crops, seed size, etc. In general most states recommend rates as stated on the label, using from 3-4 oz a.i./cwt. See Table 2.

VII. Application Equipment

Early developed seed treatment fungicides were applied as dusts, however, almost since the registration of captan it has been applied as a slurry. In a survey of the ten largest vegetable seed treating seed houses only 3 were using small amounts of dust only on cucurbit crop seeds. Today wet treatments using concentrated powders formulated for such use are applied by slurry machines in a closed system. No drying of seed is required because less than one percent of moisture is added to the seeds. Other advantages include greater uniformity and accuracy of dosage applied, less chance for workmen exposure, and less "sloughing off" of the chemical from the treated seed. A small amount of captan may be applied as a pellet such as on onion seed for smut. The development for use of captan on cut potato seedpieces required special equipment for metering the dust over the pieces as they are cut on the farm.

VIII.Precautionary Measures

Most large scale applications to crop seed are made with slurry equipment in a closed system with adequate forced air ventilation in use. Even so of the 100 seedsmen surveyed, 9 had mandatory rules for use of masks. Estimates were given by them that 18,560 man hours/yr were required to treat seed. Potato treatments on cut seed are done on the farm. Captan has a very low dermal toxicity rate, an attribute that all seedsmen stated in their preference for it when alternatives were available. Appendix B.

IX. Role of Captan Seed Treatments for Vegetables

Anyone familiar with America's technology for producing vegetables must be cognizant of the very important role that captan plays in insuring a reliable stand in the fields planted under all environmental conditions. Its control of seed rot and pre-emergence damping-off has been proven since the early 1950's. Crops such as peas, snap beans, dry beans, and sweet corn especially benefit. The ten largest vegetable seedsmen in the U.S. are uniform in their opinion that captan is unique and must be kept in registration. The two substitutes, thiram and lesan, registered on a limited number of crops are not used for several reasons, mainly because of irritant properties (thiram) or a limited spectrum of effectiveness against soil fungi (lesan).

All 50 states experiment stations and extension services recommend captan on the vegetable seeds discussed in this report. These recommendations are unanimous for peas, beans, and sweet corn. Captan is registered as a seed treatment on 29 vegetable crops and Cornell University scientists (Abawi, Sherf, Cetas) recommend it on ten.

Seed treatment is a phase of true I.P.M. by insuring healthy seedlings and removing some pathogens from the seed surface. Application of effective chemicals on concentrated plant tissue in a closed system using a chemical with a 4 day half-life is certainly a conservative use of pesticides.

X. Other Registered Seed Treatment Fungicides

Each year the American Phytopathological Society publishes the results of Fungicide-Nematicide test work done by state experiment station research and extension pathologists. Many experimental compounds as well as registered materials are reported on. Over the years a few experimental compounds have shown some promise only to be discarded for a variety of reasons, phytotoxicity, lack of broad spectrum, cost, dermal toxicity, etc. Out of these many trials only thiram and lesan have remained as competitors. Lesan is very specific against Pythium but must be used in combination with another fungicide to gain broader protection. It is rapidly degraded by sunlight also. It is several times as toxic as thiram and does not compare at all to captan (oral LD/50 is 64 mg/kg for lesan and 9000+ mg/kg for captan). With the exception of beets, lesan would need to have a broader spectrum of activity, be cheaper, and be used only against specific fungi.

Thiram as a seed treatment has its limited place usually because of its irritating qualities experienced by many who work with it even if only in handling treated seed in the farm planting operation (3, 12, 14, 15, 27, 36). Most of the seedsmen surveyed said they used thiram in a limited manner because of this characteristic (Appendix B). Its main use today is in combination with captan on sweet corn or by some on cabbage, onions, and vine crops. Seedsmen do not regard it as a viable alternative to captan for the reasons stated above.

Table 1. Usage of captan and thiram on vegetable seed.

Crop	Value ($10)	Acres (x1000)	Seed Used (x1000 lbs)	Captan Acres (x1000)	Treated %	Captan Lbs ai (x1000)	Thiram Treated %
Peas	128	415.79	208	353.3	85	200.0	10
Snap Beans	195.7	400.12	40,010	320.0	80	64.8	15
Dry Beans	475.9	1418.70	141,800	851.2	60	58.0	10
Sweet Corn	257.8	630.90	9,463	504.7	80	18.0	15
Misc. Veg.		?		?	70	8.0	10
Beets							
Carrots							
Cabbage							
Cucurbits							
Peppers							
Onions							
Potato Seedpiece	1222.3	1278.90	25,578	358.1	28*	491.0	
Grand Total				2387.3		839.8	

*Additional 10% mancozeb treated

Table 2. State recommendations for captan as a vegetable seed treatment - 1980.

Code

B = Beans SC = Sweet Corn BT = Beets CR = Carrots O = Onions

P = Peas PS = Potato Seedpiece CB = Cabbage PP = Peppers CU = Cucurbits

Alabama	B,P,PS	Montana	--------
Alaska	--------	Nebraska	B,SC,PS,BT,CR,PP,O CU
Arizona	B,PS,BT,CB,PP	Nevada	--------
Arkansas	B	New Hampshire	B,P,SC,PS,CB,CR,CU
California	PS	New Jersey	PS,PB
Colorado	B,P,PS,PP	New Mexico	B,P
Connecticut	PS	New York	P,SC,PS,BT,CU
Delaware	PS,CB,O	North Carolina	B,P,PS
Florida	B,PS	North Dakota	PS
Georgia	B,SC,PS,PP	Ohio	--------
Hawaii	--------	Oklahoma	B,P,CU
Idaho	B,P,SC,PS,CR,CU	Oregon	B,P,SC,PS,CB,CU
Illinois	B,P,SC,PS,BT,CB,CR, PP,O,CU	Pennsylvania	B,P,SC,PS,BT,CB, PP,CU
Indiana	B,SC,PS,BT,CB,CR, PP,O,CU	Rhode Island	B,SC,PS,BT,CB, CR,PP,O
Iowa	B,P,SC,PS,BT,CB,CR, O,CU	South Carolina	PS,CB,PP

Kansas	B,P,SC,PS,BT,CB	South Dakota	--------
Kentucky	B,PS,BT,CB,CR,CU	Tennessee	B,P,SC,PS,CB,CU
Louisiana	B,SC,PS,CB,CU	Texas	B,P,SC,PS,BT,CR
Maine	--------	Utah	--------
Maryland	PS,CB	Vermont	SP,CB
Massachusetts	B,P,SC,BT	Virginia	B,SC,PS
Michigan	B,SC,BT,CB,CR	Washington	B,P,SC,PS,CR,CU
Minnesota	B,P,SC,CB	West Virginia	--------
Mississippi	--------	Wisconsin	B,P,SC,PS,BT,PP,CU
Missouri	--------	Wyoming	BT

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APPENDIX A

New York State College of Agriculture and Life Sciences
a Statutory College of the State University
Cornell University

Department of Plant Pathology
334 Plant Science Building, Ithaca, N.Y. 14853

March 10, 1980

Gentlemen:

The fungicide Captan that you and other seedsmen have been using so successfully as a seed treatment since 1955 will be placed on the RPAR list of the EPA on June 9, 1980. The National panel of 14 scientists and economists has undertaken the task of defending the need for captan as a seed protectant for corn, beans, cereals, flower and vegetable seeds. We need your help with information regarding your use of this chemical on these seeds, an estimate of your annual usage in pounds, substitutes or competitive products, and especially your evaluation of its benefits.

To make this easier for you, you may merely insert figures on the enclosed questionaire. We welcome other comments or statements that you may wish to make regarding your evaluation of captan and its need to be continued in registration. If we are not successful, captan may be lost to agriculture.

On behalf of our Captan-RPAR Committee, I thank you for your help in this undertaking.

Sincerely,

Arden F. Sherf, Professor

AFS:rb

Enclosure

CAPTAN QUESTIONNAIRE

Your response will remain confidential as no company names will be attached to the summary figures.

	CROP SEED	METHOD OF APPLICATION		Captan used annually		Substitutes		
		Slurry	Dust	Lbs.	Formulation	Chem.	Lbs.	Formulation
Example:	Snap beans	S		300	75%	Thiram	150	50%

1. How many man hours are treatment operators exposed?
2. Are protective clothing and masks used?
3. Your reasons for using captan seed treatment such as growers request it, state recommends it, ensures better stands, etc.

FIRM NAME ____________________

ADDRESS ____________________

Thank you for your cooperation. Please return to A. F. Sherf, Plant Path. Dept., Cornell University, Ithaca, NY 14853

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIX B. STATEMENTS FROM COMMERCIAL SEEDSMEN APPLYING CAPTAN TO VEGETABLE SEEDS.

Joseph Harris Seed Co.
Moreton Farm
Rochester, NY 14624

We are using Captan because it has proven to be an all around good fungicide which protects a wide range (practically all) of our vegetable seeds from soil-borne fungi. This insures our growers good stands even under adverse conditions, and they have been pleased with its use.

We have and are continuing to run extensive treatment tests under a wide range of conditions of soil temperature, moisture, etc., and find Captan among the best, if not the best fungicide available today.

For certain conditions we add to the Captan other treatments. An example is Vitavax 200 for the control of head smut. We especially prefer Captan because with very few exceptions (a few people are allergic to it) it does not irritate the nose, eyes and throat like Thiram and other treatments do.

For the 12-14 years we have used Captan as a seed treatment we have had no illnesses because of its use. As mentioned above a few people develop an allergy - skin rash - to it and these people are given jobs not connected with treated seed).

We especially like the Evershield formula of Captan as it binds the Captan more closely to the seed and has practically no dusting off during handling.

We have never had a case of toxicity to seeds from Captan. We have with other chemicals where they have sifted off and settled to the bottom of the package and given the bottom of the package overtreatment of seeds.

We feel very strongly that the use of Captan should be continued. We would be lost without it, our customers would have a difficult time getting good stands without it and in turn consumers would be forced to pay a higher price for vegetables.

D. V. Burrell Seed Growers Co.
405 North Main
Rocky Ford, Colorado 81067

Several years ago we stopped using Thiram in favor of Captan. Our tests show that Captan does an excellent job and is not nearly as irritating to handle as Thiram.

I certainly hope you are successful because our opinion is that Captan is by far the easiest to use of any seed treatment we have ever applied and is the least irritating.

Robson Seed Farms
Hall, New York 14463

Captan is our main seed treatment. We use it for two reasons. First, it works! We have run side by side field emergence trials using the same variety, lot, size, planted on the same date, same field. The only difference is one batch of seed was treated with Captan, the other not treated. The results were plain. The Captan treated seed emerges uniformly and produces a good quality crop. The untreated seed has poor emergence usually at least 50% less than the treated material. The rows of untreated seed have gaps, then several plants, then gaps again. The second reason we use Captan is that we believe it to be safe. We've used Captan for years as a seed treatment with no noticeable effects on any of our personnel, wholesale customers or retail customers.

The following is our estimated annual usage of Captan seed treatment;

Crop Seed	Method of Application	Captan used annually
Sweet corn seed	Slurry	1000 lbs. - 75% Form.
Summer squash seed	Slurry	100 lbs. - 75% Form.
Field corn seed	Slurry	1000 lbs. - 75% Form.

I have not listed substitutes as we feel Captan is the best. Thiram can be use but we don't like it due to its odor.

In summary, Captan seed treatment works with a minimum of inconvenience. We have experienced no negative effects by using Captan.

Keystone Seed Co., Inc.
Box 1438
Hollister, CA 95023

We have used Captan as our standard fungicide for over 20 years. Our Research Department has conducted tests in the past and concluded that in their opinion Captan performed the best for control of the pathogens that cause damping-off in peas and beans.

In the many years we have used Captan, even the old drytreat, we have never had any ill effects to our employees, some of whom had treated seed for many years. Of course, during the time before the flowables came on the market our employees used dust face masks.

We feel to lose Captan as a fungicide would have extreme detrimental effects

Our data [illegible]

[illegible]

planted on the same date, [illegible]

seed was treated with [illegible]

[illegible] treated [illegible]

[illegible]

ed materials. [illegible]

[illegible] result. [illegible]

[illegible] used [illegible]

on any of [illegible]

lowing is the estimated annual [illegible]

[illegible] Method of [illegible]

[illegible]

listed substitutes [illegible]

[illegible]

Certan seed treatments [illegible]

ceed no negative effects [illegible]

[illegible]

[illegible]

on seed producers, food processing industry, fresh market growers and agricultur in general.

Most of our customers in the above categories specify Captan treated seed on their orders.

After 25 years of experience with Captan, it's hard to believe any one could wan to take away the registration of such a beneficial product to mankind.

Rogers Bros. Seed Co.
P.O. Box 1647
Idaho Falls, ID 83401

We appreciate your efforts to retain Captan. We feel it is essential to insure seedling emergence of many crops and should not be banned until a satisfactory substitute is available.

Asgrow Seed Co.
Upjohn Co.
Kalamazoo, MI 49001

We use Captan as a vegetable seed treatment because it gives good stand insurance with broad spectrum protection against soil fungi and may be the only effective product available.

Certainly there is ample evidence of need for an effective fungicide on these vegetable seeds. We understand Thiram is under attack and its manufacturers may not have much interest in fighting to retain it. Presently Thiram is the only practical substitute for Captan, it is not as broad spectrum (I understand), it is irritating to skin and respiratory membranes, and it may go off the market.

If Thiram and Captan were lost, there would be no highly effective fungicide available for seed treatment. This could have very bad consequences for vegetable growers, in our opinion.

POTATOES

I. Commodity Information

Potato production in the U.S. averaged slightly more than 1.3 million acres during each of the past three years and yielded an estimated annual gross return of more than 1.2 billion dollars to the growers. Although every state produced some potatoes, approximately seventy-five (75) percent of the commercial production was located in ten (10) states across the northern border.

II. Pest Information

The temperate climate of these northern states is especially favorable for the production of high yields of excellent quality tubers and unfortunately it is suitable also for many organisms which are pathogenic to the plants. Several of these pathogens, notably *Rhizoctonia solani*, *Pythium* spp., *Erwinia* spp., *Alternaria solani*, *Streptomyces scabies* and *Fusarium* spp. are more or less omni present, while others, expecially *Phytophthora infestans* are limited in distribution to areas of high humidity and frequent rainfall.

III. Captan Use

Captan is recommended as a cut-seed-piece treatment on potatoes by 33 of the 50 states and it is estimated that 377,000 acres or 27% of the commercial acreage is planted with captan treated seed. Its use by commercial growers for purposes other than seed-piece treatment is limited.

Captan is generally rated as one of the most effective seed protectants available when applied as a dust. Slurry treatment is less effective because it inhibits suberization and often causes the treated seed pieces to become slimy. The popularity and more extensive use of captan is restricted by the fact that applicators experience breathing difficulties while working and by the fact that planting machinery often do not function properly.

An analysis of experimental data published annually in the Fungicide and Nematicide tests from 1965-1979 revealed that 44 of 78 tests resulted in increased yields due to seed treatment. The percentage increased ranged from 0-326% with a mean of 21%. During the period 1961-65 an on the farm survey was conducted in Idaho (12) which included 784 fields of potatoes totaling more than 42,000 acres. In 206 fields captan was used as a seed piece treatment and 581 were planted with untreated seed. No significant difference in yield was recorded in 1962 and 1965, failure to treat the seed resulted in a significant reduction in yield in 1962 and 1963. Although those fields which were planted with untreated seed in 1964 produced yields equal to the regional average, those fields which were planted with captan treated seed yielded 13.1 cwt/a or 8.7% higher than the regional average. In 1963 fields planted with captan treated seed yielded 9.0 cwt/a or 4%

higher than the regional average.

Fungicides are applied to potato seed pieces as a protectant to prevent decay caused by soil-borne organisms such as *Erwinia* spp., *Fusarium* spp. and *Pythium* spp. They are also applied as a disinfectant to prevent infection of emerging seedlings by tuber-borne pathogens such as *Streptomyces* spp., *Rhizoctonia solani* and *Verticillium* spp. It is also necessary to consider the role of soil-borne pests such as the seed corn maggot (13).

Use Practices -- bacterial decay (*Erwinia* spp.) captan is not generally considered to be effective bactericide. In fact, it has frequently been reported that treated cut seed pieces which must be held in storage due to inclement weather often develop a wet slimy soft rot (7).

Fusarium decay -- captan is probably the least effective of the several chemicals available for seed piece treatment (5).

Scab -- captan is relatively ineffective for the control of *Streptomyces* spp. (7, 8).

Rhizoctonia solani -- treatment of seed pieces with captan has consistently been reported to decrease the incidence and severity of Rhizoctonia but this control has not consistently resulted in increased yields (3, 4, 5). The effect of *R. solani* on yield is questionable (9).

Verticillium spp. -- the use of captan as a seed piece treatment for the control of verticillium wilt does not appear to be of value (19).

IV. Exposure Hazards

on the regional average

are applied to [illegible]

ay caused by so[illegible]

pp. and *Pythium* spp. [illegible]

r[illegible]ection of average seed]

Rhizoctonia spp. [illegible]

to consider [illegible]

(13).

[illegible] bacterial [illegible]

considered [illegible]

ly been reported that [illegible]

due to inclement [illegible]

[illegible] -- caution to [illegible]

tools available for [illegible]

copper is relatively [illegible]

[illegible] 8]

[illegible] solani -- treatment [illegible]

been reported to [illegible]

this control was not [illegible]

4, 5). The effect of [illegible]

[illegible] spp. -- the use of copper [illegible]

control of varietal [illegible]

Captan is a broad spectrum fungicide which is non-phototoxic and has for many years been considered one of the safest compounds available. When used as a dust in potato cutting and treating operations good ventilation is essential and dust masks should be required along with protective clothing. The use of captan dust as a seed piece treatment has frequently, but not always, been reported to result in increased stands, improved plant vigor and increased yields. These benefits cannot always be correlated directly with control of specific pathogenic organisms. Nielson (16) stated that "all fungicides increased yields from heavily contaminated stocks by (7% to 100%) but that "no fungicide yields from lightly contaminated seed stocks." He further stated that "captan and dithane gave the largest yield increases". Cetas (5) stated that "the increases in yield due to fungicidal treatments appeared to be the result of the increase in the number of plants that emerged and the number of tubers per hill. Weingartner (21) remarked "the most striking observation in this test was the increased rate of emergence associated with some fungicidal treatments even though (seed piece) decay was negligible". Other researchers have reported similar observations.

V. Alternative Registered Fungicides

The EBDC compounds, Manzate, Mancozeb, and Dithane M-45, are generally rated equal to or superior to captan as broad spectrum seed piece protectants. The fungicide, mertect, has been consistently reported to be more effective as a protectant against Fusarium decay but is somewhat phytotoxic when used alone (2). The combination of mertect

with Dithane M-45 or Orthocide (captan) dusts overcomes this adverse effect (9) and has given superior results. There are no other fungicides registered for use.

Several researchers (2, 1, 17, 18) have noted that whole tubers planted as seed or cut-pieces properly suberized do not particularly benefit from seed treatment. This alternative is biologically feasible, even desirable, but is a questionable practicability. The production and selection of properly and uniformly sized whole tubers would be difficult and the construction of physical facilities to cut, suberize and store cut seed pieces so as to meet grower demands at planting time would require considerable additional capital investment.

VI. Summary

Alternaria solani is a ubiquitous pathogen which is the incitant of the disease known as early blight. Although the economic importance of this disease is often disputed it can result in serious defoliation of potatoes.

Phytophthora infestans, the incitant of late blight, is troublesome only in regions of high humidity and/or frequent rainfall.

Captan is recommended for the control of these diseases in only 3 states and is not considered to be an effective compound.

Table 1. Acres, production, and value of potatoes, reported states, 1977-79 average 1/

Area and State	Area Planted2/	Harvested: Area2/	Yield3/	Production2/	Value Per CWT4/	Value Per Acre5/	Total Value6/
	1,000 Acres		CWT	1,000 CWT	Dollars		$1,000
East:							
Alabama	18.7	17.3	129	2,237	8.37	1,080	18,731
Connecticut	2.0	1.9	232	440	6.05	1,404	2,662
Delaware	5.3	5.1	215	1,094	4.14	890	4,530
Florida	31.3	30.1	198	5,958	6.00	1,188	35,759
Illinois	2.2	2.0	211	422	3.02	637	1,273
Indiana	6.5	6.2	222	1,377	4.30	955	5,922
Louisiana	2.5	2.2	75	164	5.69	427	933
Maine	119.7	117.0	237	27,677	3.77	893	104,412
Maryland	1.5	1.5	159	238	4.08	649	971
Massachusetts	3.6	3.6	226	815	6.04	1,365	4,920
Michigan	42.5	40.9	242	9,915	4.33	1,048	42,945
New Jersey	8.5	8.3	256	2,121	4.00	1,024	8,480
New York	49.2	45.7	278	12,702	4.29	1,193	54,499
North Carolina	17.6	17.3	152	2,630	5.93	901	15,606
Ohio	12.7	12.1	229	2,766	4.43	1,014	12,251
Pennsylvania	26.3	24.8	250	6,208	4.80	1,200	29,792
Rhode Island	4.1	4.0	235	941	4.43	1,041	4,167
Tennessee	4.4	4.4	90	396	7.65	689	3,029
Vermont	0.8	0.8	233	186	6.43	1,498	1,196
Virginia	27.2	26.4	121	3,206	4.86	588	15,582
Wisconsin	58.0	54.8	319	17,458	4.03	1,286	70,281
Total	444.6	426.4	232	98,951	4.43	1,028	437,941
West:							
Arizona	6.2	6.2	250	1,549	5.96	1,490	9,225
California	58.8	58.0	349	20,218	5.75	2,007	116,249
Colorado	46.5	45.8	274	12,551	2.74	751	34,328
Idaho	356.7	351.7	262	92,237	2.78	728	256,043
Iowa	1.8	1.6	209	335	4.04	844	1,355
Minnesota	80.0	77.3	201	15,536	2.83	569	43,994
Montana	8.3	8.2	240	1,968	4.38	1,051	8,616
Nebraska	8.5	8.1	230	1,865	3.95	909	7,366
Nevada	15.3	15.3	330	5,050	2.64	871	13,326
New Mexico	3.8	3.7	229	847	3.84	879	3,252
[illegible]	[illegible]	[illegible]	165	20,747	2.69	444	55,877

POTATOES

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Oregon	65.1	63.5	417	26,449	2.78	1,159	73,508
South Dakota	7.0	6.5	177	1,152	3.03	536	3,485
Texas	17.8	17.4	202	3,507	7.03	1,420	24,669
Utah	5.3	5.2	246	1,281	3.78	930	4,839
Washington	107.3	107.3	467	50,070	2.54	1,186	126,944
Wyoming	6.5	6.2	219	1,360	3.51	769	4,769
Total	924.2	907.7	283	256,722	3.07	869	787,845
United States1/	1,368.8	1,334.1	267	355,673	3.45	921	1,225,786

Table 1. Acres, production, and value of potatoes, reported states, 1977-79 average - Footnotes

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1/ Excludes minor production in states not listed in the table. The Statistical Reporting Service did not publish potato data in 1979 for the states excluded.

2/ Calculated from annual data in the UDSA, ESCS, Crop Reporting Board, Crop Production, 1979 Annual Summary, CrPr2-1(80), January 15, 1980.

3/ Derived by dividing Production, column 4, by Harvested areas, column 2.

4/ Derived by dividing Total value, column 7, by Production, column 4.

5/ Derived by multiplying Yield per acre, column 3, by Value per CWT, column 5.

6/ Calculated from annual data in the USDA, ESCS, Crop Reporting Board, Crop Values, 1977-1978-1979. Season average prices received by farmers and value of production, CrPr2-1(80), January 22, 1980.

Seed Treatment

Farm Survey 61-65

R. E. Ohms, Ext. Pot Spec.

Treatment	No. Fields	No. Acres	Cwt/A	Fiducial Limits
1961				190.9-208.1
No. Treatment	107	4,069	185.6	5.3/cwt/A
Captan	11	3,047	196.2	-----
1962				169.7-181.7
No. treatment	133	12,126	179.7	-----
Captan	27	1,727	177.2	-----
1963				209.0-225.2
No. treatment	111	3,674	206.3	2.7/cwt/A
Captan	42	3,578	231.5	+9.0/cwt/A
1964				145.4-159.2
No. treatment	135	4,470	146.0	-----
Captan	65	9,280	163.4	+13.1/cwt/A
1965				
No. treatment	92		194.8	-----
Captan	61		210.3	-----

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TURFGRASSES

I. Commodity Information

Turfgrasses are used throughout the world for the purpose of environmental modification and contribute greatly to the activities and well-being of our society. In addition to providing attractive surfaces for outdoor leisure, recreation and sports activities, turfgrasses play a significant functional role in urban living through soil stabilization, heat dissipation, reductions of noise and glare and control of environmental pollutants thereby contributing to an enhanced quality of living.

Due to the functional and aesthetic value of turfgrasses in improving the quality of living, the geographic distribution of this commodity is primarily centered within populated areas of the United States. Recent estimates of turfgrass acreage in the states of New York and Texas were 1.18 and 3.1 million acres, respectively. Estimates of turfgrass in New York (9) indicate 65% of the state's turf acreage was accounted for by residential properties and even higher percentages would be expected in other states. A higher ratio of owner-occupied housing units in Texas (64.7%) when compared to New York (47.3%) could account for a higher acreage estimate in Texas. Based upon population data for the two states, estimates of managed turfgrass acreage range from 14-54 million acres in the United States (Table 1).

Trends in the culture of turfgrasses in recent years have popularized the use of intensive turfgrass management practices on homelawns as well as on public, commercial and institutional properties. Recent growth of the $950 million/yr lawn care industry in the United States reflects this trend. Maintenance of high quality turfgrasses places greater emphasis on the need for disease control using fungicide programs. Increasing emphasis on disease control of turfgrasses for functional, recreational and aesthetic uses adds considerably to intensively managed turfgrasses (1.28 million acres) found on golf course facilities (National Golf Foundation Information Sheet ST1, 1980).

Annual maintenance expenditures for turfgrass are very high. Estimates of annual maintenance expenditures for turfgrass in New York ranged from $314-595 million, while a similar estimate for Texas totaled $600 million. The National Golf Foundation estimated $870 million was spent in 1979 to maintain 11,966 golf courses in the United States. The greatest overall cost of maintaining turfgrasses in the United States is for residential lawn care. According to the 1977 housing survey conducted by the U.S. Bureau Census, total housing units (including multiple family units) in the U.S. exceeded 84 million with 64.8% of this total representing owner-occupied residences as a national average. Using the minimum estimated turfgrass maintenance expenditure of $50 for home lawns obtained from the New York study (Guttadaurio et al, 1978) estimates of annual maintenance costs for U.S. home lawns exceed $2.6 billion. Considering depreciation of expensive lawn care equipment and increased costs of lawn care products, this figure could easily be

[illegible] the use of [illegible]

as well as public convenience [illegible]

of the $150 million [illegible]

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doubled.

The principle marketed turfgrass commodities are sold as sod and as seed. Wholesale values of turfgrass and sod range from $3000-$5000 per acre and turfgrass seed valued at $2-5.00 per pound. Seeding rates for newly established turfgrasses can vary from 0.5-8 lb/1000 sq.-ft., while seeding rates for overseeded turfs is 25-40 lbs/1000 sq.-ft.

Turfgrass maintenance practices vary widely depending on the use. Highly maintained turfgrasses require intensive care and places high demands on requirements for irrigation, fertilization, mowing costs and pest control. In contrast, low maintenance turfgrasses can require essentially no care.

II. Pest Information

Turfgrass diseases that are controlled by captan are both diseases of the foliage and soil-borne diseases such as damping-off. Consultations with fungicide manufacturers, golf course representatives and turfgrass seed producers indicated the greatest use of captan fungicide is for seedling disease control for annual overseeding programs used each year in the southeastern U.S. Brief descriptions of the registered uses of captan follow. Detailed descriptions of the diseases indicated have been compiled by Britton (1969) and by Couch (1974).

a. Damping-off, seedling blights (*Pythium* spp., *Fusarium* spp., and *Rhizoctonia solani*).

The term "damping-off" refers to seedling diseases of all types of seeded turfgrasses and is caused by one of several soil or

seed-borne pathogens. Seedling diseases are usually associated with the direct loss of seedling stands; however, these diseases can also reduce growth of roots and contribute to delayed growth during establishment. The occurrence of seedling diseases of turfgrasses is an important problem on newly established turfgrasses and is also a common problem following fall overseeding on warm season turfgrasses grown in the South. The stage of seedling growth is used to classify types of damping-off as to pre-emergence seed rots and soil-borne or foliar disease development on tender seedlings. Seedling blights caused by species of _Fusarium_ and _Rhizoctonia_ are favored by warm soil temperatures and low soil moisture while species of _Pythium_ are favored by cool temperatures and high moisture levels.

Applications of captan for controlling seedling diseases of turfgrasses can be made as a seed treatment, as a preplanting seedbed treatment or as a post-planting spray following the seeding operation. Label use rates for captan as a seed treatment are 2.2-9.0 oz a.i./100 lbs of seed applied as slurry or 6 oz a.i./100 lbs seed applied as a dry formulation. The use of captan as a seed treatment fungicide for overseeded grasses (7-8 million lbs annually) has been replaced by the use of koban treated seed because of greater effectiveness in controlling Pythium diseases. As a result of the extensive use of koban seed treatment, captan is seldom used for this purpose.

Use of captan as a seedbed drench prior to planting involves application of 1 lb a.i./100 gallons of drench/100 sq.-ft.

which is cultivated into soil at a depth of 3-4 inches prior to seeding. An alternative to drenching is to apply captan as a dust at the rate of 5 - 7.5 lbs a.i./acre before cultivation into the soil profile. Seedbed preparation using captan for newly established turf appears to have limited application in residential plantings throughout the United States. The use of koban treated seed is widely used as an alternative disease control method. Following the seeding operation, captan can be used at a rate of 4.35 lbs a.i./acre as a spray or 4.3 - 9.8 lbs a.i./acre as a dust following planting or to seedling stands. Dust applications of captan are seldom used by commercial operators and this type of application is primarily restricted to occasional use on home lawns. Application of captan prior to the initiation of disease activity is recommended for optimum disease control. Repeat foliar applications at 7-14 day intervals may be necessary where favorable disease situations persist. Most of the captan used on turf is applied as a spray on dormant warm season grasses on golf greens prior to overseeding in the southeastern United States. A successful method used for overseeded golf greens in the South is to start applications of captan 50W one month before the overseeding operation in order to reduce populations of damping-off pathogens. As many as three applications of captan are commonly used for this purpose. The first application of captan at 10.9 lbs a.i./acre is followed by two foliar sprays at 4.3 - 10.9 lbs a.i./acre to the seeding operation.

b. Helminthosporium diseases (Drechslera, Bipolaris and

<u>Exserohilum</u> spp.)

Helminthosporium diseases which cause leaf, crown and root infections of turfgrasses are major problems throughout the United States. This group of diseases affects almost all turfgrass species and disease activity may occur throughout the growing season. Helminthosporium diseases are primarily spread by spores produced on infected leaves or within the thatch layer of turfgrasses. Symptoms caused by Helminthosporium diseases on various turfgrass hosts are leaf spot, fading out, melting out, leaf blotch, and root and crown rot. Helminthosporium diseases can destroy large areas of turf under conditions of severe disease activity; however, these diseases also cause foliar blighting which lowers aesthetic value of turf. Limited success has been achieved in the control of Helminthosporium diseases by use of turfgrass management programs designed to reduce disease activity, thus turfgrass managers rely heavily on foliar fungicides for disease control.

Recommended rates for application of captan to control Helminthosporium diseases are generally the same as those listed for post-planting sprays used for seedling disease control. Fungicide spray programs using captan at labelled rates of 4.35 lbs a.i./acre are used prior to infection and symptom development. An application interval of 7-14 days is recommended for disease control during environmental periods favoring disease activity. In the North, rates of captan as high as 6.8 lb a.i./acre are necessary to control leaf and crown rot infection on turfgrasses

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interval of 7-14 days is recommended [illegible]

periods [illegible]

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during warm humid weather during summer.

c. Gray leaf spot of St. Augustinegrass (Piricularia grisea)

Gray leaf spot is primarily a problem on common St. Augustinegrass grown throughout the southern United States. The disease can be a serious problem on St. Augustinegrass grown in coastal regions of the South including California. Leaf spot symptoms are the result of conidial infections of the leaf blade. Severe disease activity can cause complete foliar blighting; however, affected turf usually recovers following fungicide application. Disease activity is favored by warm temperatures and long periods of moisture-saturated atmosphere on turf receiving high nitrogen fertility. Recommended rates for application of captan are the same as that recommended for control of Helminthosporium diseases.

d. Brown patch (Rhizoctoni spp.)

Brown patch is an important disease on most turfgrass species grown throughout the United States. The disease is primarily a problem during warm, humid conditions and can spread very rapidly. Symptoms of foliar blighting cause circular areas of dead grass which can range from a few inches to 50 feet in diameter. Brown patch is often associated with the direct loss of turf although disease severity can be influenced by nitrogen fertility, mowing height and irrigation practices. Rhizoctonia solani is the primary causal agent of the brown patch disease; however, a related disease caused by Rhizoctonia cerealis (L. L. Burpee, 1979) is active when cooler temperatures are present and is called cool-season

brown patch. Rhizoctonia oryzae causes a leaf spot disease on St. Augustinegrass; however, the disease is of minor occurrence in the South. In the Northern states and Atlantic coastal area, brown patch can occur throughout the summer; however, in the Midwest and Western states, the disease is usually greatest during the spring and fall because high temperatures restrict disease activity during summer. Recommended rates for application of captan are the same as those listed for controlling Helminthosporium diseases.

e. Dollar Spot (Sclerotinia homeocarpa)

Dollar spot appears in late spring and early summer when the weather is warm and moist. Small diseased spots of turf appear as sunken areas of dead foliage; however, under severe conditions spots can coalesce to destroy large areas of turf. The disease can result in large areas of dead turf if timely control measures are not employed. The dollar spot disease occurs on major turfgrasses planted throughout the United States and is particularly severe under conditions of high or low nitrogen fertility coupled with moisture stress. Bentgrass greens on golf courses in the northern region of the United States are highly susceptible to the dollar spot disease. In the South, bermuda-grasses and zoysias are primarily affected during the summer and fall months. Recommended rates for application of captan are the same as that recommended for controlling Helminthosporium diseases.

f. Copper spot (Gloeocercospora sorghi)

Copper spot is primarily a problem on bentgrass. Small reddish spots on leaves can be damaging enough to cause a leaf blight. Field symptoms of the disease often resemble dollar spot and damage to affected turf is similar to the dollar spot disease. The disease is primarily a problem in the northeastern states. Rates recommended for captan are the same as those recommended for controlling Helminthosporium diseases.

III. Pesticide (Captan) Use on Turfgrass

The primary use of captan on turfgrasses is for preventive disease control on overseeded golf greens in the southern United States. The fungicide is used as a foliar spray on dormant warm season grasses prior to the overseeding operation. Application of captan as a seed treatment for turfgrasses has largely been replaced by koban seed treatment because of greater effectiveness in Pythium disease control. Captan is occasionally used as a foliar spray in controlling Helminthosporium diseases, gray leaf spot, brown patch, dollar spot and copper spot diseases of turfgrasses. However, its usage has largely been replaced by alternative fungicides.

The acreage of turfgrass treated with captan is unknown but the bulk of product is sold for seedling disease control on overseeded golf course greens in the southern states. Captan is not used for seedling disease control on overseeded golf course fairways because treatment costs are considered to be too high. An estimated 3000 acres of golf

greens in the South are overseeded with cool season grasses. While captan is used extensively for seedling disease control on golf greens, other fungicides (including koban seed treatment) are used for the same purpose. Estimates of turfgrass treated with captan can be derived from calculations based upon tons of products sold in various regions of the United States. Ortho and Stauffer marketing experts estimate that a total of 23,470 lbs a.i. of captan are used annually on turfgrasses. An estimate of acreage treated has been attempted and a value of 1,797 acres of turfgrass treated with captan is the result (Table 3).

Principle captan products marketed for use on turfgrasses are listed in Table 4. A number of fungicide mixtures containing captan are available from companies other than Chevron or Stauffer, but these are minor usage compared to those listed in the table. The majority of captan used for application to turfgrasses is sold as Orthocide 50 WP.

IV. Application Techniques

a. Methods and timing

All captan fungicide used on turfgrasses are applied with ground based equipment. Aerial applications of the fungicide are not common because of the restricted accessibility of many types of turf and proximity to densely populated urban areas. The primary use of captan is through application as foliar sprays using wettable powder formulations (Orthocide 50 WP, Orthocide 80 WP, Captan 50 WP, Captan 80 WP). Due to properties of broad-spectrum turf disease control by captan it is rarely used in combination with other fungicides. Most of the captan used for turfgrass

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disease control is applied by professional grounds-keepers, golf course maintenance employees, sod producers, etc. Due to increasing costs of grass seed and other supplies involved in over-seeding dormant turfgrasses, plus the intensive labor demands required for the operation, it is important to establish new turf the first time around and overseeding usually relies on the use of a fungicide program. For control of seedling diseases of over-seeded golf greens in the southern states, three foliar sprays of captan are applied to dormant turf in the fall, at 14-day intervals beginning one month prior to the overseeding operation. A fourth foliar spray can be applied following the overseeding operation to insure disease control on seedling stands. Captan may be applied at 7-14 intervals as a continued program of broad-spectrum disease control depending on the severity of disease pressure. Professional turfgrass managers adopt all or part of this disease prevention program depending on the level of disease pressure. Occasional use of captan as a ground spray in lawn seedbed preparation prior to seeding requires cultivation to a depth of 3-4 inches prior to seeding. This application has limited use due to demands on equipment and time required to perform the operation.

Captan is occasionally used for control of brown patch, leaf spots and root rots of turfgrasses as a disease preventative and is applied prior to infection and development of disease symptoms. Effective disease control requires periodic applications of captan during periods favoring disease activity. Irrigation of turfgrasses treated with foliar applications of captan is usually

withheld for several hours following application in the control of leaf spot diseases. Root disease control using captan is generally considered more effective when light irrigations are used to wash the fungicides into the thatch and soil profile beneath the turfgrass plot. In most instances applications of captan as foliar sprays are not immediately followed by irrigation. Direct use of captan as a dust on turfgrasses is primarily limited to residential use. Application is accomplished by direct dusting of 7.5-50.0% a.i. captan dust or powder on turfgrass foliage. Application can be repeated at 1-2 week intervals as necessary.

The use of captan for treatment of turfgrass seed is considered to be infrequent; however, when used as a seed treatment the operation is largely performed by commercial seedsman. Captan can be used as a powder formulation mixed with seed or as a slurry for wet application to seed.

b. Application rates

The label-recommended rates for captan fungicides are listed by disease and by product in Tables 2 and 4. The estimated number of applications/year for disease control are also listed in Table 2. Captan products manufactured by Ortho and Stauffer are established at standard use rates applicable for disease control throughout the United States. Captan fungicide rates recommended for turf use by Ortho range from 4.35 - 9.8 lbs a.i./acre. Most Ortho products sold for use on turfgrasses are used at the rate of 4.35 lbs a.i./acre. Stauffer fungicides containing captan are used at the rate of 4.35 lbs a.i./acre. Disease control programs

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United States. Captan fungicide rates

by Ortho range from 0.25 - 0.5 lbs a.i./acre.

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employing the use of captan are estimated to require 1 - 3 applications annually; however, use of captan throughout the growing season could require as many as 5 applications annually due to the presence of disease activity during the spring and fall seasons.

c. Application equipment

Foliar applications (Orthocide 50 WP, Orthocide 80 WP, Captan 50 WP, Captan 80 WP) are usually accomplished using boom-type spraying equipment. Suspensions are applied to 100 to 400 gallons of water per acre. Fiberglass tanks of 55 to 300 gallon capacity are common and are usually equipped with a mechanical or hydraulic system for agitation. Fungicide suspensions are delivered to a spray boom commonly equipped with tee-jet nozzles and delivery pressures of 30 to 100 psi are used for foliar sprays. Captan wettable powders are added to the tank by dumping a portion or all of the contents of the bag by hand through a fill well at the top of the mixing tank. The vehicle used for spray equipment is usually of the open-cab type design where the applicator is positioned in front of the vehicle and the tank and spray boom trail behind. The spray boom and delivery system in this instance is usually located more than five feet behind the operator of the vehicle. Some orchard-type mist-blowers are also used on golf courses; however, their use appears limited because of improvements in equipment in recent years.

As many as three workers could be involved for 1 hour in adding fungicide and water to the mixing tank and testing the

equipment before the fungicide is applied. Application using power equipment is typically accomplished by one employee. Application of fungicide to greens of an 18 hole golf course requires about 4 hours and an additional estimated time of 8-10 hours is required to treat fairways. An estimated 5 acres/hour could be treated using this equipment.

Golf course employees and commercial applicators also use hand-held wands as power spraying devices. Wands are located at the end of long hoses which supply fungicide from the mixing tank. This type of equipment is mostly used on golf course greens and spot-treatment of fairways. In recent years this approach for fungicide application has also become popular in the treatment of residential turfgrasses by lawn service companies. Usually two workers are involved in application of fungicide in this manner. Time involved for treatment is similar to that estimated for power boom spraying equipment.

The use of captan by homeowners for controlling turfgrass disease is limited to occasional use. Captan can be used as a dust or ground spray for seedbed preparation in the planting of turfgrass seed. Various types of garden dusters or disposable containers used as a shaker duster can be used for dusting captan on seedbeds. An alternative to dusting is application of captan as a ground spray which is usually accomplished with a hand-held pressurized sprayer. Home use of captan for spot treatment of diseases on established turf is usually accomplished using the same methods of application. Time requirements for home use

application can vary widely depending on the size of the treatment area; however, the application time would not exceed 0.5 hours in most cases.

d. Precautionary measures

Protective equipment is rarely used by workers who apply captan to turfgrasses. When protective equipment is used by applicators, usually this consists only of rubber gloves during the mixing operation. Generally normal attire is worn by applicators who apply fungicide commercially or for home use. No re-entry periods have been established for captan on turfgrasses. Caution is advised in the contamination of open water sources because of potential toxicity to fish. Applications are usually withheld where air turbulence could cause drift to consumptive food products or increased contact to applicators.

V. Post-Application Activities

Golf course play and home lawn activities are generally not interrupted by captan application to turfgrass. Application of foliar sprays on golf courses are usually accomplished in the early mornings when player traffic is at a minimum. The intensity of foot traffic on golf courses is higher than that occurring on other types of treated turfgrasses.

VI. Exposure Hazards

a. Workers

Three forms of exposure to dust, powder or spray mist of captan by applicators are inhalation, dermal contact and oral ingestion. A recent study by W. A. Small (1978) demonstrated the greatest exposure of five foliar fungicides used in golf course maintenance occurred during solution preparation. Similar data could be expected following the use of captan wettable powder. Inhalation can occur when captan powders or dusts are emptied into mixing tanks or dust applicators. Particulate dust also arises as a result of opening and closing of product bags or other containers. Visibility and accuracy of adding powder to mixing tanks is often restricted by the small size of the fill well located at the top of the tank which creates inhalation problems from spilling and close facial contact. Inhalation of spray mist can also occur in the treatment of greens due to directional changes of the vehicle required to perform this operation.

Dermal contact can occur through contact with powder or dust during the dispensing and mixing operations or through contact with spray solutions in adjustment or cleaning of spray nozzles or by walking over freshly treated turf. A limited amount of oral ingestion could occur due to intake of dust, powder or spray into the mouth.

b. Public

Exposure of the public to captan can occur when foliar sprays are applied on windy days, when recreational or leisure activities continue on treated turf or when golfers lick golf balls or hands after picking up contaminated playing equipment. An important

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source of dermal contact exposure would be expected where golfers wear water absorbent shoes during play on treated turfgrass.

VII. Role of Captan

Environmental relationships and turfgrass management practices play a major role in governing the extent of disease activity on turfgrasses. Modification of cultural practices with respect to irrigation, fertilization, soil aeration, drainage and soil pH as well as changes in mowing height, frequency and the removal of thatch are measures which are useful for limiting disease activity. The use of management practices as means of reducing disease activity on golf greens is limited due to the necessity of maintaining grass at a low cutting height with high fertility and irrigation frequency to counterbalance heavy traffic and cultural requirements for the sport. Golf greens management programs which supply balanced fertility at moderate levels and irrigate turf during the early morning hours to avoid drought and long periods of moisture retention on turf foliage are helpful in reducing brown patch, dollar spot and Helminthosporium diseases. The manual removal of dew reduces the moisture and nutrients on turfgrass leaves and is a management tool used for the control of brown patch and dollar spot. This practice has limited application because once disease activity is initiated fungal pathogens can be spread by methods conventionally used for the removal of dew.

In general, cultural programs designed for the production of actively growing turf can limit disease activity on intensively managed turf. Avoiding stress and maintaining adequate water balances on turfgrasses as well as supplying balanced nutritional programs have proven to be helpful in this regard. Past experience of professional turfgrass managers have shown that disease control can not entirely rely on management programs for suitable disease control on disease susceptible turfgrass cultivars. Outbreaks of turfgrass diseases during environmental periods which encourage disease activity must rely on additional control measures which are capable of contending with higher levels of disease pressure.

The search for disease resistant turfgrass cultivars has received much attention in recent years. The usefulness of disease resistant turfgrass varieties is restricted because of the number of potential disease problems that can occur. Resistance of turfgrass cultivars to Helminthosporium diseases or to the dollar spot disease may be complicated by their increased susceptibility to brown patch or other diseases that could be very damaging. Most diseases of turfgrasses are caused by facultative fungal pathogens which have increased severity on a weakened host. Resistance or tolerance to disease development can be greatly reduced by the occurrence of various types of stress due to intensive management practices required for many types of turfgrasses. The development of new pathogen races capable of breaking resistance of turfgrass cultivars can reduce the effectiveness of varietal resistance to relatively short periods. The highly variable nature of turfgrass pathogens has resulted in pathogen strains capable of causing disease on

most resistant turfgrass cultivars in use.

An added complication in the development of resistant varieties for turfgrass is the need for good agronomic characteristics associated with the cultivar. Varietal resistance to a multitude of disease problems coupled with good agronomic qualities appear to be rare among turfgrasses studied. The use of varietal resistance to control diseases of turfgrasses should be considered valuable as an aid to disease control; however, the limited disease resistant cultivars presently available do not satisfy the requirements for disease control on intensively managed turfgrasses.

Captan is but one of the fungicides used for controlling diseases of turfgrasses. Captan is inexpensive and competitive with alternative fungicides which can be used for disease control on turfgrasses. The relative importance of captan with respect to other fungicides is evaluated in the next section.

VIII. Alternative Registered Fungicides

<u>Damping-off, seed rot, seedling blights</u> -- Previous sections of this report have emphasized the principle use of captan as a pre-plant fungicide treatment on overseeded golf course greens in the southern states. Widespread use of captan in overseeding programs can be attributed to activity of the fungicide against many pathogens associated with seedling diseases. Captan is not used for seedling disease prevention on large acreages of turf such as overseeded golf fairways or commercial installations of newly established turf because of the high cost of treatment. Koban seed treatment is widely used as a

cost effective seedling disease control measure on large acreages of seeded turf. Due to higher disease pressure with increased levels of management on golf greens, koban seed treatment should be supplemented with foliar fungicide sprays to provide adequate disease protection. The use of koban treated seed followed by foliar sprays of chlorothalonil, thiram, iprodione, cycloheximide, anilazine, benzimidazoles, and EBDC fungicides have proven to be equally effective in disease control programs for overseeded greens. The low cost of captan fungicide is offset by the number of applications required for disease control. The cost of using koban treated seed with supplemental fungicide treatment with thiram as a foliar spray is estimated to be less than the cost of captan programs currently used on overseeded turf (Table 6). Longer periods of disease protection can be expected using alternative fungicides listed above. The necessity of applying fungicide can be reduced as the disease pressure dictates. The use of alternative fungicides mentioned can also be employed for home lawns where captan is used for seedbed preparation in the planting of newly established turf. The use of thiram for seedbed application is effective for broad spectrum disease control and should be considered as a low cost alternative to captan ground treatment prior to seeding.

Helminthosporium diseases, Gray leaf spot of St. Augustinegrass -- Foliar sprays of captan are effective for controlling Helminthosporium diseases of turfgrasses and gray leaf spot of St. Augustinegrass when repeated applications are applied at regular intervals. Helminthosporium and gray leaf spot diseases are not controlled as effectively by captan as by chlorothalonil, analazine, maneb or

Due to higher disease pressure

on golf greens, which are

ir fungicide appears to provide adequate

of brown patch

Dithane, Fungicide

Clor, and TUPC fungicides have been shown to be effective

control programs for greens.

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iprodione fungicides. Carbamate fungicides such as mancozeb, nabam and zineb are also useful alternatives for control of leaf spot diseases as well as thiram, cycloheximide and thiophanate ethyl. Cadmium fungicides are registered alternatives for use on turf; however, their use will be subject to review by RPAR.

The use of captan for treatment of large areas of turfgrass is favored by a relatively low cost when compared to alternative fungicides (Tables 6 and 7). Systemic activity of iprodione and fungicide mixtures containing cycloheximide has been used successfully as a curative treatment for Helminthosporium diseases. The use of these fungicides results in longer periods of protection due to systemic activity. Studies on the effect of fungicides in reducing fungal spore populations on tall fescue thatch (Colbaugh 1977) have shown increased effectiveness of carbamate fungicides and chlorothalonil in eradicating dormant spores of the fungus on thatch. Captan was not effective in reducing spore populations of Helminthosporium fungi on turfgrass thatch.

The loss of captan from the fungicide arsenal would probably not result in an increase in the severity of Helminthosporium or gray leaf spot diseases of turfgrasses. Alternative fungicides are available which provide better disease control in turfgrass management programs although the cost of treatment would be higher in most cases. The low cost of captan usage is offset by alternative fungicides which provide a longer period of disease protection.

nd fungicides. [illegible]

[illegible] also useful [illegible]

ntrogen, cycloheximide [illegible]

[illegible] tered alternatives for use [illegible]

[illegible]

e use of [illegible]

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better [illegible]

e cost of treatment [illegible]

[illegible] offset by alternative fungicide [illegible]

of disease problem.

Brown patch, Dollar spot, Copper spot -- Captan is considered to be used infrequently for the control of these diseases in the Northeastern states. The use of repeated applications of captan are useful in controlling these diseases because of its general fungicidal activity against a wide range of pathogens. Other fungicides that are useful are summarized in Table 5. The use of captan for brown patch control has largely shifted to more effective fungicides such as benzimidazoles, ethylenebisdithiocarbamates, analazine, chlorothalonil and iprodione. Dollar spot and copper spot diseases are effectively controlled by applications of chlorothalonil, analazine, thiophanates and thiram although application costs are higher (Table 7). The use of benomyl for control of brown patch and dollar spot diseases is limited because of potential development of resistant strains of pathogens causing these diseases. Benomyl is used in combination with other fungicides or alternately with other fungicides to overcome this problem. Continual use of PCNB for brown patch control in Texas has also resulted in the presence of tolerant strains of the fungus.

IX. Summary of the Role of Captan Used on Turfgrass

Captan is for use in controlling Helminthosporium diseases, gray leafspot, brown patch, copper spot and seedling diseases of turfgrasses. The widest application of captan usage on turfgrass is in the control of seedling diseases and is favored by its low cost and broad spectrum of disease control activity. It is doubtful that the loss of captan would result in increased severity of turfgrass diseases. Without captan the cost of seedling disease control on turfgrass could be increased;

however, the low cost of captan is counterbalanced by its short period of disease protection.

Table 1. Turfgrass acreages in Texas, New York, and estimates for the United States (based upon population statistics).

	Texas	New York	United States
Total Population 1/	13,014,000	18,084,000	214,659,000
% New York and Texas	6.0%	8.4%	-
Metropolitan Population 2/	10,294,074	16,004,000	156,701,000
% of Total Population	79.1%	88.5%	73.0%
Metropol. % of U.S. Metropol.	6.5%	10.2%	-
Total Land Area 3/	167,766,000	30,612,000	2,263,587,000
% of U.S. Total Land Area	7.4%	1.35%	-
Est. Turfgrass Area (Acres)	3,100,000 4/	1,181,567 5/	14-54 million 6/
Residential Property	-	763,437 5/	-
Public Lands	-	205,437 5/	-
Commercial Lands	-	153,722 5/	-
Golf Courses	-	80,255 5/	-
Institutional Lands	-	58,566 5/	-
% Owner occupied housing units 7/	64.7%	47.3%	62.9%

1/ from Current Population Reports. (Series P-25). Population Estimates Projections. U.S. Dept. Commerce, Bureau of the Census. No. 646. Feb. 1977. 4 pp.

2/ from Statistical Abstract of the United States-1978. U.S. Dept. Commerce, Bureau of the Census.

3/ from Agricultural Statistics-1977. U.S. Dept. Agriculture. 614 pp.

4/ from J. B. Beard, Texas A&M University, College Station, Texas.

5/ from J. Gruttadaurio, E. E. Hardy and A. S. Lieberman. 1978. An Investigation of Turfgrass Land Use Acreages and Selected Maintenance Expenditures Across New York State. Cornell University Dept. of Floriculture and Ornamental Horticulture Report. 36 pp.

6/ Estimated by dividing New York and Texas turfgrass acreage estimates by 8.4% and 6.0%, respectively.

7/ from U. S. Bureau of Census Annual Housing Survey-1977 part A. General Housing Characteristics.

Table 2. Turfgrass controlled by captan; a ranking of emphasis place on captan relative to alternative fungicides; and the efficacy, application rates, annual application numbers, and range of possible costs for captan products.

Disease	Emphasis1/	Efficacy2/	Appl. Rates (lbs a.i./acre/appl.)	ca. Numbers of appl. annually3/	Range of costs of captan4/
Seedling diseases (damping-off, seed rot)	1	G-M	4.35	1-3	$14 - 48
Helminthosporium diseases	2	G-M	4.35	1-6	$14 - 96
Grey leafspot	3	E-M	4.35	1-3	$14 - 48
Brown patch	4	G-P	4.35	1-4	$14 - 64
Dollar spot	5	G-M	4.35	1-4 (up to 12)	$14 - 64 ($192)
Copper spot	6	G-M	4.35	1-3	$14 - 48

1/ Dependence upon captan as determined from the National Pesticide Information Program summary for captan's i.e. a collation of states reporting the use of captan and achieving effective disease control with it.

2/ E = excellent, G = good, M = moderate, P = poor. Efficacy varies among regions and on various grass species.

3/ from National Pesticide Information Program summary for captan and from product labels.

4/ Maximum range of annual application numbers and costs/acre/application (from Table 4).

Table 3. Estimates of captan used on turfgrasses and estimated turfgrass acreage treated with captan.

I. Assumptions: (based upon calculations with industry spokesman)

a. 17,430 lbs a.i. captan used annually on overseeded golf greens in the southern United States.

b. Use of captan on home lawns is estimated to account for 1% of the home and garden products sold as captan fungicide (3,630 lbs a.i.).

c. Limited use of captan for controlling foliar disease of turfgrasses throughout the U.S. is estimated to be 2,000 lbs a.i. Golf course fairways and greens, commercial and recreational facilities.

II. The Captan - turfgrass market can be divided a follows:

a. (90%) Chevron (Ortho)

Orthocide Home & Garden Products	3,630 lbs a.i.
Orthocide 50W and 80W	17,570 lbs a.i.

b. (8%) Stauffer

Captan 50W and 80W	1,770 lbs a.i.

c. (2%) Others (formulations - Home & Garden) 500 lbs a.i.

Total 23,470 lbs a.i.

III. Estimated acres of turfgrass treated with captan fungicide (assuming three applications/yr at a use rate of 4.35 lbs a.i./acre).

a. Overseeded golf greens (southern states)	1,328 acres
b. Home lawns (U.S.)	316 acres
c. Disease control on golf courses, commercial and recreational facilities.	153 acres
Total	1,797 acres

Table 4. Principle captan-containing fungicides used on turfgrasses

Product	Formulation	% Captan a.i.	Retail 1/ cost/lb	cost/lb a.i.	Application Rate lb a.i./A	Cost/ Acre/ Application (a.i. basis)
Orthocide 80W (Chevron)	W.P.	80.0%	$2.55/lb	$3.19	4.35	$13.88
Orthocide 50W (Chevron)	W.P.	50.0%	$1.80/lb	$3.60	4.35	$15.66
Orthocide 7.5 Dust (Chevron)	W.P.	7.5%	$0.53/lb	$7.07	6.5-9.8	$46-69
Orthocide 10 Dust (Chevron)	W.P.	10.0%	-	-	4.4-8.7	-
Orthocide 4F (Chevron) Seed Protectant	F.	32.5%	-	-	-	-
Captan 80W (Stauffer) (East of Rockies)	W.P.	80.0%	$2.64/lb	$3.30	4.35	$14.35
Captan 80W (Stauffer) (West of Rockies)	W.P.	80.0%	$2.64/lb	$3.30	4.35	$14.35
Captan 50W (Stauffer) (East of Rockies)	W.P.	50.0%	$1.80/lb	$3.60	4.35	$15.66
Captan 50W (Stauffer)	W.P.	50.0%	$1.80/lb	$3.60	4.35	$15.66

1/ Based on price obtained from manufacturers in Dallas and Houston, Texas. Captan as 50W or 80W powders are available as 50-lb balers containing 12 4-lb bags.

Table 5. Most commonly suggested alternatives to captan for turfgrass disease control.

Alternatives	Turfgrass Disease					
	Seedling Diseases	Helminthosporium Diseases	Gray Leafspot	Brown Patch	Dollar Spot	Copper Spot
Benzimidazoles (including benomyl, thiophanates)	X	X		X	X	X
EBDC´s (including maneb, nabam, mancozeb, and zineb)	X	X	X	X	X	X
Cadmium Fungicides		X		X	X	X
Cycloheximide	X	X	X		X	
Anilazine	X	X	X	X	X	X
Chlorothalonil	X	X	X	X	X	X
Iprodione	X	X		X	X	
Thiram	X	X	X	X		X
Terrazole	X					
Chloroneb	X					
PCNB				X		

Table 6. Estimated cost (per acre a.i.) of captan and alternative fungicides used for control of seedling diseases and Helminthosporium diseases of turfgrasses.

Fungicide	Retail Cost/lb1/	Cost/lb a.i.	Seedling Diseases: Use Range (lbs a.i./A)2/	Seedling Diseases: Application Cost/Acre (a.i.)	Helminthosporium Diseases: Use Range (lbs a.i./A)	Helminthosporium Diseases: Application Cost/Acre (a.i.)
Orthocide 50W (Captan)	$ 1.80	$ 3.60	4.35 - 10.9	$15.66 - 39.24	4.35	$15.66
80W (Captan	2.55	3.19	4.35 - 10.9	13.88 - 34.77	4.35	13.88
Tersan 1991 50W (Benzimidazole)	11.80	23.60	2.72	64.19	-	-
Tersan LSR 80W (Maneb)	2.50	3.13	6.55 - 8.71	20.50 - 27.30	6.55 - 8.71	20.50 - 27.30
Cadminate 60W (Cadmium)	17.40	29.00	-	-	-	-
Anti-Dione-Thiram 75W (Cycloheximide-Thiram)	5.64	7.52	4.08 - 8.16	30.68 - 61.36	4.08 - 8.16	30.68 - 61.36
Dyrene 50W (Anilazine)	3.00	6.00	5.44 - 8.17	32.64 - 49.02	5.44 - 10.89	32.64 - 65.34
Daconil 2787 75W (Chlorothalonil)	5.55	7.40	8.17 - 12.25	60.45 - 90.65	8.17 - 12.25	60.45 - 90.65
Chipco 26019 50W (Iprodione)	15.60	31.20	1.36	42.43	2.72	84.86
Tersan 75W (Thiram)	2.21	2.95	6.10 - 9.14	18.00 - 26.96	6.10 - 9.14	18.00 - 26.96
Kóban 35W (Terrazole)	11.90	34.00	3.81	129.54	-	-
Tersan S.P. 65W (Chloroneb)	8.32	12.80	7.08	90.62	-	-
Terraclor 10G (PCNB)	0.34	3.40	1.00 - 3.30	3.40 - 11.22	-	-
75W (PCNB)	2.07	2.80	1.00 - 3.30	3.40 - 11.22	1.00 - 3.30	3.40 - 11.22

1/ Suggested consumer retail costs/lb as quoted September 1, 1980.
2/ Use range as suggested by manufacturer.

Table 7. Estimated cost (per acre a.i.) of captan and alternative fungicide used for control of brown patch, gray leafspot, dollar spot and copper spot diseases of turfgrasses.

Fungicide	Retail Cost/lb	Cost/lb a.i.	Brown Patch: Use Range (lbs a.i./A)	Brown Patch: Application Cost/Acre (a.i.)	Gray Leafspot, Dollar spot, Copper spot: Use Range (lbs a.i./A)	Gray Leafspot, Dollar spot, Copper spot: Application Cost/Acre (a.i.)
Orthocide 50W (Captan)	$ 1.80	$ 3.60	4.35	$15.66	4.35	$15.66
80W (Captan)	2.55	3.19	4.35	13.88	4.35	13.88
Tersan 1991 50W (Benzimidazole)	11.80	23.60	2.72	64.19	1.36 - 2.72	32.09 - 64.19
Tersan LSR 80W (Maneb)	2.50	3.13	6.55 - 8.71	20.50 - 27.30	6.55 - 8.71	20.50 - 27.30
Cadminate 60W Cadmium)	17.40	29.00	-	-	0.81 - 1.63	23.49 - 47.27
Acti-Dione-Thiram 75W (Cycloheximide-Thiram)	5.64	7.52	4.08 - 8.16	30.68 - 61.36	4.08 - 8.16	30.68 - 61.36
Dyrene 50W (Anilazine)	3.00	6.00	5.44 - 10.89	32.64 - 65.34	5.44 - 8.17	32.64 - 49.02
Daconil 2787 75W (Chlorothalonil)	5.55	7.40	8.17 - 12.25	60.45 - 90.65	8.17 - 12.25	60.45 - 90.65
Chipco 26019 50W (Iprodione)	15.60	31.20	1.02 - 1.36	31.82 - 42.43	1.02 - 1.36	31.82 - 42.43
Tersan 75W (Thiram)	2.21	2.95	6.10 - 9.14	18.00 - 26.96	6.10 - 9.14	18.00 - 26.96
Koban 35W (Terrazole)	11.90	34.00	-	-	-	-
Tersan S.P. 65W (Chloroneb)	8.32	12.80	-	-	-	-
Terraclor 10G (PCNB)	0.34	3.40	1.00 - 3.30	3.40 - 11.22	-	-
75W (PCNB)	2.07	2.80	1.00 - 3.30	3.40 - 11.22	-	-

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ORNAMENTALS

I. -Commodity Information

Ornamentals are grown for aesthetic and ecomonic purposes throughout the United States. Specific plants and settings vary with the climate and interests of the different parts of the country. Crops and situations where captan and folpet are used for ornamental use may be arbitrarily grouped into 3 categories as follows:

a. Commercial production of ornamentals

Total wholesale value in 1977 was estimated at $1.6 billion, which in turn generated some $4.8 billion in retail sales. An estimated 1,100 genera of plants are grown as ornamentals, many of which are infrequently produced.

1. Floriculture crops, e.g., cut flowers, pot plants and foliage plants produced in glass-, cloth- or lathhouses, or outdoors. Includes production of cuttings. U.S. wholesale value of these crops in 1977 were estimated at $1.0 billion. Foliage plants have enjoyed the greatest increase of these crops in recent years.

2. Bedding plants e.g., annuals grown under glass for outdoor planting. Ornamental bedding plant annuals in 1977 were valued at a wholesale value of $81.5 million (vegetable transplants equaled $31.5 million). This was an 80% increase over the 1970 value.

3. Nursery crops include production of trees, shrubs, vines and perennials, primarily produced out of doors, and grown for 1 to 5 years. The 1977 wholesale value was estimated at $576.8 million.

4. Bulb crops, e.g., bulbs, rhizomes, tubers and corms, comprised an estimated 1977 value of $20.8 million.

5. Seed crops, including annuals and perennials had an estimated value of $3.2 million in 1977.

These data were obtained from Baker and Linderman (1979), who in turn had extracted the figures from reports by M. T. Fossum (Fossum, M. T., 1977. Economic trends and projections for commercial floriculture. United States, 1951-1986. Washington, D.C. Marketing facts for floriculture, Ltd. 9 pp.).

Commercial growers have a particular obligation to produce healthy, disease-free plants. Not only is their reputation, and consequently their economic stability influenced by the appearance and performance of their crops, but also the availability and distribution of healthy plants to the buying public is a fundamental process in the protection and successful propagation of plants in their ultimate setting.

b. Public parks, institutional grounds, and related industries

Data have not been developed to reflect value of ornamentals in public and institutional settings, but trees, shrubs and perennials are highly regarded by the public. Individual trees

of any size may be valued from $500 to $5,000 or more.

Care and maintenance of these crops is big business. The number of grounds keepers, golf course superintendents, arborists, park superintendents and related professionals have not been tabulated, but their employment must be considered as a part of this phase of the industry. Similarly, supportive industries, including garden centers and similar organizations that service the home owner's gardening needs and appetites are considered a part of this segment.

c. Statistics have not been developed to quantify home garden activity very substantially. However, in 1977 there were reported to be some 32 million home gardens in the United States, of which about 75% used some form of pesticide. It is estimated that about 10% of all homeowners use captan or any fungicide. Folpet is used in small quantities.

II. Pest Information

Ornamental diseases that are controlled by captan are incited both by foliar and root pathogens. Consequently, applications of captan may be applied either to foliage with conventional foliar (and flower) application equipment, or it may also be incorporated into the soil prior to planting, or applied as a water-suspended drench to plants at any stage of their production. Soil treatments most frequently are applied to seedlings, or early stages of propagation, sometimes as a dip of the propagative part (e.g., cutting, tuber or corm) prior to

establishment. Captan has moderate effectiveness against the two major genera of soil-borne root-invading pathogens: (1) Pythium and (2) Rhizoctonia.

Captan activity against all pathogens, either soil or foliar are essentially protective, with relatively little capacity to effectively eradicate pathogens that have already invaded plant tissue. They are not systemic. Consequently, they are applied in a schedule that is designed to anticipate infection periods, often requiring several applications during a growing season. This is comparable with use of these chemicals on other crops. Captan is frequently combined with insecticides for simultaneous application. Thus, compatibility is important. Captan is also combined with other fungicides on less frequent occasions.

The diseases registered and labelled for captan use are listed in Table 1. Detailed description of these diseases can be found in Wescott's Plant Disease Handbook (1971). Most of the foliar and flower pathogens are multicyclic. That is, spores of the pathogens are produced during favorable periods throughout the growing season. Protection is required during these times. Typical applications consist of 1-2 pounds of formulated product per 100 gallons, applied for coverage (102 tablespoons per gallon in small quantities). Their greatest ornamental use is upon roses, although commercial use of captan for carnations and chrysanthemums may be substantial.

Captan is sold and/or recommended for use in virtually every state and territory of the United States.

III. Role of RPAR´D Pesticides - Captan - In Ornamental Disease Control

Captan usage has averaged between 45 and 50,000 pounds of active ingredient for commercial greenhouse and ornamental use per year over the last 5 years. Pattern of use has been rather constant. The distributors include Chevron Chemical Company, Stauffer Chemical Company, and Rohm and Haas Company. The latter´s product is manufactured for them by the Solchem Company. Comsumption data were provided by Mr. Harry Gaede, EPA, and they concur rather well with data provided privately by respective companies.

Homeowner captan use data for ornamentals are estimated at approximately 106,0000 to 160,000 pounds of active ingredient over the same period of time. These data are much more subjective, since homeowners purchase a considerably higher quantity of product than the figure, according to industry figures, but it is used for fruit and vegetable crops as well as ornamentals. As much as 90% of homeowner captan purchases may go on the fruit crop, according to one industry estimate.

Another factor in assessing patterns of use, and need for the chemical, is a consideration of the number, or percentage of growers, using the product to control their disease problems. Some survey information exists to help with this assignment. A 1977 Ohio nursery pesticide use survey revealed the fact that more nurserymen used captan (21.2%) than any other fungicide, although not as much total product was

used when compared with some other compounds. (Nurseries were producing fruit trees as well as ornamental crops.) One reason for its apparent popularity was its broad spectrum labelling and a long history of safe use without phytotoxic or other problems associated with it.

It should be noted that these data suggest popularity of chemical usage, but do not address critical need of a product. A small use on a specialty crop could be vital to the production of that crop in a given disease situation or location without reflecting a high use pattern of the product. Nor do they necessarily address the possibility of successful substitution with an alternative chemical. That subject will be discussed later.

Captan has been widely recommended and available for ornamental disease control for over a quarter of a century. The first captan garden and home label was issued on October 10, 1955 (personal communication, Mr. Desmond Byrne, Chevron Chemical Company, April 23, 1980). It is used, or recommended for the control of certain ornamental diseases for commercial or homeowner use in 20 of 22 states where such information was provided the committee by state pesticide impact assessment coordinators.

One of the reasons often stated for captan popularity is the broad label it carries. Captan is registered for a wide spectrum of crops, including the most commonly grown fruit crops, many vegetables, turf, and ornamentals. Moreover, it is registered and labelled for soil and drench applications, plant and product dips, as well as more commonly used foliar and fruit sprays. It is compatible with most organic pesticides, and with a relatively few exceptions, is not phytotoxic to

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Dr. Desmond Hunt [illegible] April 22,

need, or recommended for [illegible]

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[illegible]

crops.

However, ornamental registrations are not comprehensive. Moreover, product labels often do not contain crops or diseases for which captan is registered and labelling varies from product to product. Such information is summarized in Table 1 for captan.

Table 1. Registered and/or labelled captan uses for ornamentals

Captan labels with ornamental uses

a. Registered uses 1/
b. Ortho Orthocide 50W 2/
c. Ortho Orthocide 10 dust 2/
d. Ortho Orthocide 7.5 dust 2/
e. Captan 50W (Stauffer) 3/
f. Captan Garden spray 3/
g. Captan 50W (Rohm & Haas) 4/

Crop	Disease	Applicable Labels
Azalea	damping off	a, b, e, f, g
	petal blight	a, e
Begonia (tuberous)	damping off	a, e, f
	tuber rot	a, e, f
Camellia	petal blight	a, e
Carnation	rust	a, b, c, d, e, f, g
	Alternaria leaf spot	a, b, c, d, e, f, g,
	damping off	a, b, e, f, g

Chrysanthemum	flower blight	b, c, d, g
	Botrytis flower blight	a, e, f, g
	Septoria	a, e, f, g
	damping off	a, b, e, f, g
Conifers	seed treatments	a
Gladiolus (corms)	corm rot & decay	a, e, f
	damping off	a, e, f
Hollyhock	anthracnose	a
Lilac	anthracnose	a
Rose	black spot	a, b, c, d, e, f, g
	Botrytis blossom blight	a, e, g
Snapdragons	anthracnose	a
spirea	anthracnose	a
Stock	Botrytis	a, c
Soil & Greenhouse treatment, preplanting for damping off and root disease for "roses, other shrubs and trees, and many flowers".		a, b, c, d, e, g

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1/ USDA compilation of registered uses of fungicides and nematicides. June 1, 1979. Preliminary edition.

2/ Ortho 1980 Product Guide. December 1979.

3/ 1980 Speciality Chemical Manual for lawns, turf, shade trees, ornamentals. Stauffer Chemical Company.

4/ Agricultural Chemicals Manual, Rohm and Haas Company, 1979.

Tradition, grower experience, and in some instances, lack of awareness regarding label legalities, has resulted in uses and recommendations on ornamental crops much broader than crop and site registration. For example, Walsh examined the Cornell University disease control suggestions in 1974 and found captan offered for use on 15 floriculture crops and 24 diseases. Only 8 of these were registered! This procedure continues to some extent. For instance, computer printouts of 1979 extension recommendations for one state listed 25 captan suggestions, 9 of which were not registered.

Reasons for this discrepancy can readily be appreciated by an examination of the plethora of ornamental crops that exist, and the vast number of disease situations that can befall the ornamental crops grown, and literally thousands of disease and site situations that can develop (USDA Handbook No. 165), only a small percentage are mentioned specifically on fungicide labels. The captan registration contains only 13 specific ornamental crops and 22 specific disease sites, in addition to general soil and greenhouse bench treatments (Table 1). Few other fungicides have that broad a spectrum of registration (USDA compilation of registered uses of fungicides and nematicides).

These comments are important to the committee for these reasons:

1. to demonstrate captan's broad pattern of use;
2. to illustrate the history and acceptance of the product;
3. to indicate the complexity of dealing with disease control needs of the ornamental industry and general homeowner use.
4. to point out that registration of captan for ornamental purposes is not nearly as extensive as is commonly alleged to be.

IV. Alternative chemicals for captan

Alternative chemicals registered to control the diseases for which captan is also registered, are contained in Table 2. Basic information for the table was obtained from the USDA Compilation of Registered Uses of Fungicides and Nematicides, dated June 1, 1979. Those chemicals in parentheses were added by examination of current labels of several fungicides that were considered to be good replacement candidates.

Candidate replacements are available for most of the diseases listed. However, most of the products are not regarded as viable substitutes. Some are registered, but not generally available, such as several of the copper-containing compounds. Others have restrictions to greenhouse and/or commercial use only, such as diazoben or parnon. Still others, such as cycloheximide and dodine, will cause phytotoxicity when applied on a season-long basis or under certain environmental conditions. Maneb, for instance, can cause burn to chrysathemum flowers when applied to water-soaked flowers resulting from rain, fog or dew (Cox, 1971). A few, such as copper-containing chemicals and ferbam, are incompatible with other chemicals that may need to be applied at the same time. Several of the most effective and readily available fungicides that have the broadest host spectrum belong to the EBDC group - the "ethylene bisdithiocarbamates" (e.g., maneb, zineb, mancozeb, polyram, nabam). Unfortunately, this group is now under RPAR review, too, and cannot be relied upon as dependable replacements. Replacement of captan would be made much more difficult by the simultaneous loss of EBDC's.

Several benzimidazoles are listed as candidate replacements, including benomyl, thiabendazole, and thiophanate-methyl. While these products were recently cleared through RPAR procedures, resistant fungal strains have surfaced dramatically following their sustained use. They are ineffective now in many areas for rose black spot and powdery mildew control, for instance. Manufacturer and extension recommendations now encourage alteration of benzimidazole chemicals in the spray schedules, or combining benzimidazoles with chemically distinct fungicides, such as captan. They cannot be relied upon alone for control of any pathogen on a long term basis. Triforine is a product just recently registered which shows promise in controlling a few specific diseases, for which captan is registered, but it does not have a broad spectrum of effectiveness, and resistance may develop with triforine if used simply in a schedule over a long period of time.

Captan is not uniquely effective against all diseases for which it is registered. In a few situations, however, researchers report it to be the most effective chemical available. Dr. Ralph Baker, Colorado State University Plant Pathologist, reports the following in a communication to Dr. Bert Bohmont, Colorado Agricultural Chemicals Coordinator:

> "Captan has been used extensively in pathogen-free propagative operations since 1954 in Colorado. Between 7-10,000,000 carnation cuttings are produced every year in Colorado and all mother plants receive weekly or bi-weekly sprays of captan for control of potentially the most important disease of carnation--Fusarium stem rot.

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Dr. Mark Bennett, Cornell Agricultural [illegible]

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[illegible] on bi-weekly [illegible]

[illegible]

Losses before application of captan were 60% or more and the carnation industry would not be viable today in Colorado if captan had not been available. Benomyl can be used as an alternative spray material but, as you know, numerous fusaria (and other pathogens) have developed strains that are tolerant.

There are commercial propagators that have applied captan at weekly intervals within greenhouses since 1954. I know of no instance of injury or allergy to applicators or their offspring during that time. Cuttings covered with captan are transplanted by some 250 or more growers and I know of no harmful effects among these people."

Captan is not universally beneficial to crops when used as a soil drench. In a study specifically designed to compare captan with potential replacement fungicides, Colbaugh (1979) reported marked improvement in growth of ornamental pepper (Capsicum annum 'Fiesta') when treated with captan. Effect on zinnias was insignificant, but captan drenches reduced development and survival of Peperomia caperata, var. 'emerald purple', in his study of three crops. Certain cultivars of petunias have been damaged by captan drenches, according to grower reports. But it is generally considered to have relatively low toxicity compared with some currently available replacement fungicide drenches. Perhaps its greatest virtue over other drenches currently registered is its broad spectrum label. Many bedding plant propagators produce both vegetable and ornamental plants side by side, and they need to use the

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cted by some 25% or more [illegible]

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same drench for all crops to facilitate handling and production. To the author's knowledge only captan has broad label vegetable and ornamental registration as a soil drench to control both water mold (Pythiaceous fungi) - and Rhizoctonia - incited root diseases.

Products underlined in Table 2 represent the author's best estimate of the most acceptable alternative chemicals to captan when these factors are considered:

1. Usefulness for both commercial and home garden uses.

2. General availability, or anticipated availability of the product to the spectrum of users.

3. Acceptance efficacy with minimum phytotoxicity anticipated.

In summary, captan contains few fungicidal characteristics that would make replacement difficult for ornamental disease problems when problems are considered individually. This statement assumes replacement compounds will remain available. However, when spectrum of activity and registration is considered, and ready availability across the nation is taken into account, captan loss, particularly, would have an impact. Such loss would be especially true for small growers who need a low priced product that can be used on a number of different crops without encountering the cost and potential hazard of inventorying a larger assemblage of various products.

Table 2. Alternative fungicides for registered or labelled captan uses 1/

crop	disease	captan (c) registration/ labelled	alternative chemicals
Azalea	damping off	c	see "Soil treatment" below
	petal blight	c	benomyl, copper-zinc chromate complex, dichlone, ferbam, maneb, nabam, PCNB, thiram, mancozeb, zineb, ziram glyodin, sulfur, (benomyl)
	powdery mildew	c	glyodin, sulfur, (benomyl)
Begonia (tuberous)			
	damping off	c	ethazol - see "Soil treatment" below
	tuber rot	c	no other product registered - see "Soil treatment"
Camellia	petal blight	c	ferbam, maneb, nabam, PCNB, mancozeb
Carnation	rust	c	copper oxychloride, ferbam, folpet, nabam, oxycarboxin, sulfur and ziram
	Alternaria leaf spot	c	copper oxychloride, copper 8-quinolino-late, ferbam, folpet, maneb, zineb
	damping off	c	ethazol - see "Soil treatment" below
Chrysanthemum	Septoria leaf spot	c	ferbam, folpet, maneb, (benomyl)
	Alternaria leaf spot		copper 8-quinolinolate, folpet

ORNAMENTALS

	powdery mildew		copper 8-quinolinolate, cycloheximide, (benomyl), folpet
	anthracnose		folpet, nabam, zineb
	flower blight	c	chlorothalonil
	Botrytis flower blight	c	2-amino butane, chlorothanonil, copper 8-quinolinolate, cycloheximide, nabam sulfur, zineb, ziram, (benomyl)
	damping off	c	Botran, ethazol, thiophanate-methyl
Conifers - seed		c	thiram
Gladiolus (corms)	corm rot	c	TCMTB, benomyl, folpet thiabendazol, thiram
	damping off	c	folpet
Hollyhock	anthracnose	c	copper-bordeaux, copper oxychloride, mancozeb
Lilac	anthracnose	c	no other registered
Rose	black spot	c	polyram, benomyl, calcium polysulfides, chlorothalonil, copper-bordeaux, copper oleate, copper oxychloride, basic copper sulfate, dichlone, dodine, ferbam, folpet glyodin, mancozeb, maneb, nabam, sulfur, tributyltin, chloride complex, zineb, ziram, triforine
	botrytis blossom blight	c	chlorothalonil, COCS, copper-8-

ORNAMENTALS

Snapdragon	anthracnose	c	copper oxychloride, basic copper sulfate ferbam, folpet, nabam, zineb
Spirea	anthracnose	c	no other fungicide registered
Stock	botrytis	c	no other fungicide registered

Soil and Green house bench treatment:

Roses	c	many specific crops are registered for
Shrubs	c	ethazol, thiophanate methyl, benomyl
Trees	c	(diazoben - for commercial use only), PCNB.
Flowers	c	None are as broad-spectrum however.

1/ Information obtained primarily from USDA compilation of registered uses of fungicides and nematicides. June 1, 1979. Entries in parentheses were added from current pesticide labels. Underlined entries are those considered to be the best replacement candidate for the specific disease situation.

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Appendix to Assessment of Captan Fungicide Use on Ornamentals

A number of requests for additional information have been received following the distribution of the main text of this report. Responses to these questions are addressed and included in this appendix to the original report.

1. What is the practical availability of fungicides that could be used to replace labelled uses for captan, should other fungicides now subject to RPAR review also not be available for consideration?

   This question is difficult to answer, primarily because of the uncertainty of the RPAR position on other chemicals. The following fungicides are apparently subject to some form of RPAR or pre-RPAR review, according to a telephone conversation with Dr. Neil Pelletier, EPA, on October 27, 1980:

   Benomyl, cadmium, captafol, captan, chlorothalonil, EBDC's (mancozeb, maneb, nabam, and zineb), ethylene dibromide, folpet, methyl thiophanate, and pentachloronitrobenzene.

   Table 3 offers a modification of Table 2, accordingly, and also eliminates certain other fungicides which are not considered to be viable replacement candidates because of economics or availability.

Table 3. Alternative fungicides for registered or labelled captan, assuming products on RPAR or pre-RPAR are also not available. 1/

crop	disease	captan (c) registration/ labelled	alternative registered chemicals 2/
Azalea	damping off	c	no other product registered - see "Soil treatment" below
	petal blight	c	copper-zinc chromate complex, dichlone ferbam, (ziram), Bayleton
	powdery mildew	c	glyodin, sulfur
Begonia (tuberous)	damping off	c	ethazol - see "Soil treatment" below
	tuber rot	c	no other product registered - see "Soil treatment"
Camellia	petal blight	c	ferbam
Carnation	rust	c	copper oxychloride, ferbam, oxycarboxin sulfur and (ziram)
	Alternaria leaf spot	c	copper oxychloride, (copper 8-quinolinolate), ferbam
	damping off	c	ethazol - see "Soil treatment" below
Chrysanthemum	Septoria leaf spot	c	ferbam
	flower blight	c	none
	Botrytis flower blight	c	(2-amino butane) (copper 8-quinolinolate, sulfur), ziram
	damping off	c	Botran, ethazol
Conifers - seed		c	
Gladiolus (corms)	corm rot	c	TCMTB
	damping	c	no other registered - see "Soil treatment" below
Hollyhock	anthracnose	c	copper-bordeaux, copper oxychloride

ORNAMENTALS

Lilac	anthracnose	c	none
Rose	black spot	c	polyram, calcium polysulfides, copper-bordeaux, copper oleate, copper oxychloro-ride, basic copper sulfate, dichlone, dodine, ferbam, glyodin, sulfur, tri-butyltin, chloride complex, (ziram), triforine
	Botrytis blossom blight	c	CPCS, (copper-8-quinolinolate) Botran, ferbam
Snapdragon	anthracnose	c	copper oxychloride, basic copper sulfate, ferbam
Spirea	anthracnose	c	none
Stock	Botrytis	c	none
Soil and Greenhouse bench treatment:			
Roses		c	many specific crops are registered for ethazol,
Shrubs		c	(diazoben - for commercial use only),
Trees		c	None are as broad-spectrum however.
Flowers		c	None registered to control Rhizoctonia.

1/ Fungicides on RPAR or "pre-RPAR" lists include: benomyl, cadmium, captan, captafol, chlorothalonil, EBDC's (maneb, mancozeb, nabam, zineb), EDBC, folpet, methyl thiophanate, PCNB, and thiram.

2/ Fungicides in parentheses remain on the registration list, but are not now, and presumably will not become available for use - either because of economic and efficacy limitations.

The fungicides that would remain to control the ornamental diseases listed above, in the event that all RPAR-threatened fungicides are removed, are few in number. Table 3 gives some indication of that fact, but the situation is actually more acute than the table suggests. Those chemicals listed in parentheses are not presently available to the author's knowledge. They are older chemicals which failed to compete favorably, primarily because of efficacy problems. Some "weathered" poorly or performed unsatisfactorily, for instance.

A majority of the remaining fungicides are copper-containing sulfur products. While these products are better than no chemical at all in many instances, their performance is usually dramatially poorer than the RPAR'ed chemicals. Reduced efficacy of 25-50 percent can frequently be expected, and this is simply not adequate in most situations. Some phytotoxicity is encountered upon occasion, and unsightly blue residues are frequently objectionable on ornamentals. Sulfur is also usually as effective, and has two additional limitations: (1) greater chance of phytotoxicity, especially during warm periods, and (2) poor residual characteristics, thus requiring more frequent applications to protect many crops.

There are some new chemicals that may be registered soon that could reduce this potential threat somewhat. Bayleton has recently received registration for Azalea petal blight. A few additional ornamentals may be added, though this product is a growth regulator that causes phytotoxicity on many ornamentals. Iprodione is expected to receive registration on several ornamentals for control of Alternaria and one type of root and stem rot (Rhizoctonia). It cannot be relied upon as a

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many [illegible]. Truban is [illegible]

[illegible] for control of Alternaria [illegible]

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single fungicide, because fungal strains resistant to the fungicide have already developed experimentally.

2. What would be the production losses, should these chemicals (all fungicides subject to RPAR review) no longer be available?

A conservative estimate might be 25 percent of the crop. Economic impact would likely be substantial because the losses would not be distributed uniformly or predictably among the crops, and growers would have difficulty scheduling their crop production to meet market needs dependably. Loss ranges from 0 to 90 percent will occur, depending upon various biological and environmental factors.

3. What are the application procedures used for captan and the potential for human exposure?

Seed protectants are applied only one time per crop production season. Potential exposure is primarily to the hands, although this can be virtually eliminated by the use of protective gloves. It is not feasible to plant seed, particularly small seed in bedding plant flats with gloves, but seeding devices are in common use that can minimize hand contact.

Captan soil drenches and plant dips are used once or in some cases up to three times per production season for each crop upon which it is used. Skin contact can be avoided during the drench application. It is more difficult to handle plants while wearing protective gloves, though it would not be impossible to do so with some crops.

A substantial variation in flower and foliar application procedures for dusts and wettable powder formulations exists. They are applied as protective compounds, typically at 7 to 10 day intervals during the growing season, or the time wet weather or other conditions favor disease development. Large producers use sprayers or dusters which permit the applicator to be several feet away from the application site, such as tractor-pulled mechanically operated equipment. Smaller producers and most florists use hand-held or operated equipment, and consequently are more subject to exposure. However, in both instances it is possible to wear protective gear that would essentially eliminate contact with the products.

4. What are the benefits of a broad crop and disease fungicide label to the grower?

Captan has possibly the broadest crop label of any fungicide on the market, since it includes many vegetable, fruit, field, ornamental and turf crops, and it is registered as a seed treatment, soil drench, foliar, flower and fruit protectant. Benomyl rivals this characteristic and certain EBDC´s have equal or greater foliage and fruit labelling, but cause injury to many seeds and to most roots. The potential benefit of this characteristic is greater to the small operator, such as the part time operator, since captan is usually not as effective for any one purpose, and larger producers are quite willing to use a variety of chemicals. It is possible for most small operations to depend on only one or a few fungicides, barring unusual disease problems. No data are available to indicate whether this is the case, however. (It is not unusual for home gardeners to do so).

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The broad label also permits its use in somewhat unconventional ways. For example, captan is one of the most extensively used fungicides in treating warehouses for winter storage of plant materials. Purpose is to reduce botrytis (and other) infections which often develop over the surface of plants held at low storage.

Another common practice by many nurserymen is the addition of captan with root-promoting growth regulator hormones used on many specialty crops. This use has developed over many years of grower experiences, and is apparently accepted because of its low order of phytotoxicity to most crops, reasonably good soil fungicide activity, and low cost. Some growers use seed treatments similarly.

5. Can you provide some expanded information on the statistics of the industry?

   (a) What is the estimated number of commercial ornamentalists in the United States?

   (b) What percentage use captan?

   (c) What is the total volume of captan use for commercial production of ornamentals, and what information on regional use patterns exist?

(a) - Accurate data describing the industry are not available now. A Horticulture Specialty Crop Census report is underway by the U.S. Census Bureau, and may be available in the early part of 1981. It is estimated that there are between 24,000 and 26,000 nurseries that do between $2,000 and $10,000 of business and an additional 7,500 nurseries producing more than $10,000 of products annually. There may be as many as 30,000 retail florists in the U.S., that would use fungicides for some purpose. About 1500 of these might be considered larger growers.

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What percentage [illegible]

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Specialty [illegible] Census report [illegible]

, and may be available in the early part of 1961. [illegible]

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000 of products annually. There was [illegible]

in the U.S. that [illegible]

[illegible] might be considered larger growers.

These figures are offered following telephone conversations with several trade associations and industry leaders.

(b) - A Pesticide Use Survey a/ of Ohio nurseries in 1977-78 revealed that captan was the most commonly used fungicide among those who responded (only 11% responded but they represented 26.6% of the total acreage). Some 21.2% used captan, while 19.7% used benomyl, the next most common fungicide. It should not be anticipated that most growers would rely upon a single fungicide, because of the extreme diversity in crops grown within the industry. Consequently, the importance of a single product may be significant with one, but not all segments of the industry.

a/ Miller, Richard, L. and W. K. Roach. Ohio Pesticide Use Survey in Ohio Nurseries. Research Circular 254, January 1980.

(c) - Captan use, as reported on page 3 of the first report, is estimated at between 45,000 and 50,000 pounds of active ingredient for commercial ornamental producers. Only limited information is available concerning regional commercial use patterns, but it is recommended for some ornamental use in virtually all states by extension pathologists. Since it is used significantly in storage, and propagation practices, it probably has somewhat uniform use patterns. Certain specialty crops, such as the Colorado carnation industry, undoubtedly rely more upon the product than the industry as a whole.

6. What is the critical need for captan to the industry (subject expanded)?

Captan is a primary fungicide for the industry. It is not universally required, thus its prohibition would not destroy the industry. The data suggest that about 25% of the growers rely upon captan fungicide. Its use would increase markedly if certain other fungicides now subject to RPAR review were eliminated. Thus, it is impossible to accurately assess captan's value to the industry without taking that critical question into consideration.

Given the assumption that other fungicides will not be eliminated, it would appear that the critical needs are in these areas:

a. As a plant propagation, or soil drench treatment for specific crops. See the need of the carnation industry, offered by Dr. Ralph Baker as an example. Perhaps 20% of the ornamental growers have need for the product in this fashion.

b. As a plant materials and plant storage treatment. Estimates

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between 45,000 and [illegible]

[illegible] producers. Only limited [illegible]

gional comparison [illegible]

[illegible]

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of this value are difficult to make. Storage losses, when they occur, can be devastating - up to 100% of the crop. Control is by way of a combination of the right chemical and cultural practices followed. Loss potential may be cumulative over time. Research continues on specific crop problems. A recent report on the control of a root rot-molding complex of black walnut seedlings in storage by R. J. Green, Jr., and D. F. Plourde is attached as an illustration of this point. In this instance, captan reduced one type of mold injury by 50% when compared with the non-treated check. (Interestingly captafol (Difolatan) an analog of captan not registered for ornamental use and also under RPAR review, virtually eliminated the disease. Captafol would have even greater value than captan to the industry for control of this disease and several other important problems.) In general, many growers with a diversity of crops have found captan to have useful value in reducing Pencillium and several other general storage molds without causing serious phytotoxic problems or irritation to workers handling the crop.

A summary estimate of its value as a storage treatment must include a range effect from 0 to 100%, with an average loss of perhaps 5 to 15%. A substantial economic concern is the unpredictable nature of these type losses. Storage loss occurrence is at the whim of the environment. Without dependable control, the grower has no way to program production needs.

c. Captan is used as a flower and foliar treatment. It is the judgment of this author that a suitable substitute is available

today for most such uses (excluding other RPAR'd chemicals), except as it is used to reduce or prevent development of fungus tolerance to certain alternative chemicals. This has been alluded to earlier. Best examples are with benzimidazoles and several new fungicides just appearing on the market, including triademefon and iprodione. Examples of important ornamental pathogens where fungus tolerance is already known include Botrytis, Fusarium, Penicillium, Venturia, Sclerotinia, Erysiphe, and several others. The discussion presented in the fruit disease section has application to ornamental uses as well. Captan is very useful as a compatible fungicide for this purpose. With the exception of the EBDC's (also under RPAR review) no broad spectrum contact fungicide is as appropriate for the purpose of reducing fungus tolerance of systemic fungicides for ornamental use as is captan.

FOREST NURSERIES

I. Commodity Information

Forest nurseries annually produce 1.4 billion seedlings on approximately 9,100 acres (Table 1). These seedlings are used to outplant in excess of 1.8 million acres annually.

The total tree seedlings produced by public and private nurseries are as follows:

Federal nurseries	126,525,000
State nurseries	655,422,000
Other public nurseries	9,275,000
Industry nurseries	599,587,000
TOTAL	1,390,809,000

Most seedlings produced in federal nurseries are planted on national forest lands. Seedlings produced in forest industry nurseries are planted primarily on company land; however, some seedlings are distributed to other private landowners through various company programs.

In state nurseries, forest tree seedling production and distribution activities are conducted under the Federal and State Cooperative C-M 4 Program. The states that annually produce in excess of 30 million seedlings in nurseries are as follows: Mississippi, 63,071,000; Virginia, 59,175,000; Georgia, 56,735,000; Alabama, 54,900,000; Louisiana, 53,604,000; Florida, 48,290,000; North Carolina,

42,832,000, and South Carolina, 35,734,000.

The average cost of seedlings per 1,000 is $13.00 which makes the annual value of the seedling crop exceed 18 million dollars.

Table I. Locations and acres of tree nurseries by regions and states.

Northern Region

State	Acres
Montana	76
N. Idaho	185
N. Dakota	389
N. West S. Dakota	70
Total	720

Rocky Mountain Region

State		Acres
Colorado		146
Kansas	3,300 sq. ft.	
Nebraska		43
Total		189

Intermountain Region

State		Acres
Utah		20
South Idaho		30
Nevada	43,560 sq/ft (greenhouse)	8
Total		58

Pacific Southwest Region

State	Acres
California	280
Hawaii	18
Total	298

Pacific Northwest Region

State	Acres
Washington	981
Oregon 704,448 sq/ft (greenhouse)	747
Total	1,728

Eastern Region

State	Acres
Connecticut	14
Delaware	14
Illinois	120
Indiana	220
Maine	40
Maryland	32
Michigan	218
Minnesota	579
Missouri	64
New Hampshire	18
New Jersey	11
New York	92
Ohio	182
Pennsylvania	94
Vermont	62
West Virginia	145
Wisconsin	219
Iowa	65
Total	2,189

Southeastern Region

State	Acres
Alabama	408

Arkansas	273
Florida	511
Georgia	561
Kentucky	80
Louisiana	237
Mississippi	306
N. Carolina	300
Oklahoma	310
S. Carolina	289
Tennessee	100
Texas	231
Virginia	299
Total	3,905

Total acres in nurseries in United States 9,087

Site preparation cost for tree planting varies with regions; however, even with a very conservative estimate of $100.00 per acre the annual cost is 180 million dollars. If an adequate supply of high quality seedlings is not available, many millions in site preparation cost will be lost.

II. Pest Information

Forest seedling diseases that are controlled by captan are primarily diseases of the roots. However, for many other crops it is used for foliage and fruit diseases. Application and rates for captan may differ from practices in other commodities. The important diseases of forest seedlings are presented by Peterson and Smith (1975).

Many fungi cause damping-off disease, but the most common species are Pythium, Fusarium, Rhizoctonia, and Phytophthora. The disease causes 15-20 percent seedling loss in most years which is compensated for by nurserymen who plant 20-25 percent seed over-run to ensure good seedling stands.

Damping-off is wide spread in nurseries throughout the United States. Most conifers are susceptible with the exception of junipers. Among the hardwoods, sycamore, sweetgum, yellow-poplar and most elms are very susceptible. Green ash, oaks, and honey locusts are somewhat resistant.

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Green ash, catalpa,

The causal organisms are native to most nursery soils. Populations of the pathogenic fungi usually increase in nursery soil with each successive year of cropping, and disease losses will increase if chemical or cultural controls are not used.

Climatic conditions that reduce seedling growth usually cause an increase in disease outbreak. The disease is most severe in excessively wet soils and symptoms may appear 24-48 hours after rainy days. Temperature also influences disease development, with disease losses being higher when temperature slows seedling growth.

Control

Disease losses from damping-off can be minimized by cultural means. Losses are generally reduced by practices that increase seed-germination rate. Cold, wet soils during first 30-45 days of planting require a chemical application to ensure uniform stand.

Captan is effective in controlling damping-off if applied at time of planting. The fungicide is applied by ground rig at the rate of 4-6 lb. A.I./A.

III. Use of Pesticide in Producing Commodity

a. Geographic area of use

b. Forest nurseries are located in most states with approximately one-half produced in the South (Table 1). Approximately 1,250 acres are treated according to Clark Lantz, nursery specialist, Southeast Area, S&PF. This is about one-fourth of the total nursery area planted annually (Table II). Based on the registered

rates (5-6 lbs. per acre) the amount of captan used annually is over 6,000 lbs. A.I.

c. Pesticide products - see Table III

d. Application techniques

1. Method and time of application, captan is usually applied as a drench with ground rigs at planting or as a drench after the seedlings emerge. The latter treatment usually is applied after disease symptoms are present. Nurserymen and staff who are qualified to handle pesticides routinely apply captan.

a) The label rate ranges 3-15. The most frequent use is 4-6 lbs. A.I./A.

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Table II. Number of forest nurseries selling seedlings as bare root, in container, or both in the United States in 1975. 1/

Nursery	Bare root	Container	Both
Federal	10	4	1
State	76	5	6
Other public	3	1	6
Forest industry	33	13	5
Private	15	9	3
Total	137	32	21

1/ Total acres 9,087 approximately 50 percent of area in production annually.

Table III. Principle captan containing fungicide used in forest nurseries.

Formulations	Percent Captan A-1	Product type	Package size	Retail cost	Labelled rate
Orthocide 50	50	W.P.	5 lb bags	3.13	5-6
Captan 50	50	W.P.	3,5,10 lb bags	2.68-3.50	5-6
Captan 75	75	W.P.	50 lb drums	2.55	5-6
Captan 80	80	W.P.	50 lb drums	2.68	5-6

b) Captan is usually applied as a preemergence treatment or when seeds germinate. Most disease incidence occurs before the seedlings are 45 days old. Normally only one treatment is used per season.

3. Application equipment used

Average size tank is 200-400 gallons constructed of fiber glass. The type nozzle varies with sprayer to deliver 20-40 gallons water as carrier at 200-400 psi.

The wettable powder is usually premixed with water in a container (2-5 gal. size) before it is dumped into sprayer. Most commonly, open cab tractors are used to tow the ground spray equipment; however, some nurseries do use the close-cab tractors to tow the large 5- to 6- bed spray rigs.

The usual procedure is to use a 2-man crew, but occasionally one man does all spraying. An experienced worker can spray 5-6 acres per hour. In the southern region, fermate is applied as a tank mixture for the control of Fusiform rust.

4. Precautionary measures

a) The concerned nursery man requires his employees to use rubber gloves and wear goggles while mixing the chemical. Other nurserymen use no protective equipment, but encourage the employees to clean hands after premixing chemical for sprayer.

b) No special reentry intervals are noted by nurserymen

and have no limits on reentry time.

c) Post-pesticide treatment activities

Seedling beds treated with captan are not handweeded until 30-45 after chemical is applied. With irrigation and rainfall, the chemical is drenched into the soil leaving the seedling beds' surface relatively free of captan.

Handweeding is perform throughout the growing season. One worker can hand weed 2 acres in a 40-hr. week. In most nurseries, the number of employees used for weeding will be one-half the acres in production to ensure nursery beds are weeded weekly.

IV. Exposure Hazards.

Nurserymen are exposed to captan by inhalation and dermal contact. Inhalation is probably the most common hazard since wettable powders are most frequently used in nursery operation, while many nurserymen minimize oral ingestion by mixing wettable powders in water in small containers before dispensing chemical in spray tank. Dermal exposure can occur from contact with any chemical while it is being mixed and by spray solutions during windy days. High psi usually reduces particle-size and increases vaporization which increases chances of exposure. Further contact with captan is made when contaminated clothing and shoes are removed, cleaned, or worn again.

V. Role of Captan

Most seedling diseases can be controlled by soil fumigants (Methyl Bromide, Vorlex or Dimethyl Bromide), and other cultural practices that promote good growth. Damping-off caused by *Pythium*, *Phytophthora*, *Rhizoctonia*, and *Fusarium* causes minimal losses under normal weather conditions if good soil fumigation is accomplished. Frequently, prolonged wet weather during the spring will cause excess mortality and additional chemical control is necessary to prevent loss of seedlings. In Southern United States (regions of high rainfall in spring) the application of captan at time of planting helps minimize disease outbreak and prevents disease losses.

VI. Alternative Registered Fungicides

Captan controls *Rhizoctonia* and *Fusarium* damping-off; however, dexon and terrazole are more effective if damping-off is caused by *Pythium* and *Phytophthora*. Captan is still used for these fungi because of less expense and captan is viewed as a broad spectrum fungicide. PCNB is the chemical most widely used as a substitute for captan. Other fungicides that are useful are summarized in Table 4. North Carolina, which produces over 42 million conifer and hardwood seedlings, has no alternative fungicide registered for the control of damping-off.

VII. Summary

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Active Registered Fungicides

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Captan is used to control seedling diseases (damping-off and root rot). It is used in addition to fumigants during wet spring seasons. Fungicides are necessary to produce healthy, vigorous planting stock to ensure success in the reforestation program.

If the soil fumigant (Methyl Bromide or Dimethyl Bromide) becomes unavailable, captan or other effective fungicides would be the main defense against heavy disease losses in tree seedlings. At present, the loss of captan would probably not increase disease severity. The alternative fungicide, PCNB, could be used to replace captan for disease control.

Table IV. Most commonly suggested alternatives to captan.

Alternatives	Damping-off	Root Rot
PCNB	x	x
Dexon	x	x
Benomyl	x	
Chloranil	x	
Dichlone	x	
Thiram	x	
Terrazole	x	
Terrazole and Banrot	x	
Banrot	x	x

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HOMEOWNER USE

I. Commodity Information

Homeowners grow various types of plants for both aesthetic and utilitarian purposes. Crops and situations where captan is used by the homeowner can be categorized into four groups as follows:

1. Fruit crops, includes pome (apples and pears), drupe or stone (cherries, peaches, plums, apricots, and mangoes) small (grapes, raspberries, and strawberries) and citrus (oranges, lemons, limes, grapefruit and tangerines) fruits.

2. Vegetable crops, includes solanaceous (tomato, pepper, eggplant, potato) crops and cucurbits (cantaloupe, cucumber, muskmelon, honeydew melon, pumpkin, squash, watermelon); vegetable seed treatment is also included here (beans, corn, cabbage, melon, peas, squash, beets, chard and spinach).

3. Turf, also includes lawn and grass seed treatment.

4. Ornamental crops, includes flowering plants (azalea, begonia, carnation, chrysanthemum, and rose) and bulb dips (gladiolus, and tuberous begonia).

II. Role of Captan

a. Areas of use

Statistics substantially quantifying home garden activity are

not presently available. However, there were reported to be some 32 million home gardens in the United States in 1977, of which about 75% used some form of pesticide. It is estimated that about 10% of all homeowners use captan or any fungicide (11). Manufacturer estimates indicated that about 1.0 million pounds of captan a.i. were used by homeowners in 1972 (9). As much as 90% of homeowner captan purchase may go on fruit crops according to one industry estimate (11).

Captan has been widely recommended and available to the homeowner for over a quarter of a century. The first captan garden and home label was issued on October 10, 1955 (11). Captan is used and recommended for the control of many diseases of fruits, vegetables, ornamentals and turf for homeowner use in many states.

b. Pest information

The diseases controlled by captan in the home and garden are incited by both foliar and soil-borne pathogens. Therefore, applications of captan can be applied to the foliage as foliar sprays, or it may be incorporated into the soil prior to planting, or applied as a water-suspended drench to plants at any stage of their production. Protection against soil-borne pathogens can also include dips of the propagative plant parts (e.g., cuttings, rhizomes, tubers or corms) and seed treatment prior to establishment. Captan is a protectant fungicide, and is applied in a schedule that is designed to anticipate infection periods, thus often requiring several

applications during a growing season.

c. Formulations of captan

The major distributors of captan with labels for homeowner use are Chevron Chemical Company and Stauffer Chemical Company. Three Ortho products manufactured by Chevron (6) and one product manufactured by Stauffer (13) which contain captan as the ingredient active as a fungicide and the crops and diseases for which use is either registered or labelled are listed in Tables 1 and 2. These products are for sale in small packages in nearly all retail outlets (garden centers, nurseries, hardware, discount and department stores) for home and garden pesticides throughout the U.S.

Captan is frequently combined with insecticides for simultaneous application convenient for homeowner use. Several other manufacturers and suppliers package pesticide formulations which contain captan as the ingredient active as the fungicide (Table 3).

d. Application equipment, techniques and rates

Captan products used in the home garden are applied by hose proportioners, lawn fertilizer spreaders, low-pressure bombs, hand-operated dusters, and hand-operated or tank-type sprayers.

Dosage rates are equivalent to those recommended for commercial agricultural uses but are usually expressed as tablespoonfuls or teaspoonfuls per gallon of water (10). For example, Ortho Orthocide Garden Fungicide is mixed at the rate

of 3 1/3 tablespoonfuls per gallon of water to control most plant diseases and can be applied at 7 - 10 day intervals (5). Application rates and frequency of application can vary with the crop, however, and so labels must always be consulted prior to application (6, 13).

e. Exposure hazards

The extent of personal exposure to captan during home and garden use is not presently known. Care should be taken to avoid breathing of dust or spray mist, and contact with skin.

III. Role of Captan and Alternative Chemicals for Captan

There are alternative chemicals registered to control diseases in the home garden for which captan is also registered. Alternative fungicides available to the homeowner in small packages include benomyl, maneb, zineb, lime sulfur, bordeaux mixture, dyrene, chlorothalonil, and folpet (7). Data are not available comparing the efficacy of captan to these alternative fungicides in a home and garden situation. It is, therefore, difficult to assess the impact on the homeowner if captan registration were to be cancelled. By reviewing the assessment reports of captan fungicide uses on commercial fruit crops, vegetable crops, ornamental crops and turfgrasses, extrapolations can be made to home and garden production of the above mentioned crops.

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Cancellation of the use of captan on pome fruits (apples and pears) would create chaos in the commercial industry, especially in the apple industry (4). It is projected that captafol use and the use of EBDC fungicides would increase. Usage of benomyl and dodine would also increase and then decline due to fungicide resistance. With the possibility of captafol and the EBDC's also being cancelled in addition to captan, effective alternative fungicide spray programs would simply not be available. Captan is currently recommended for homeowner use in pome fruit spray schedules in 23 states. Zineb, maneb, EDBC fungicides and benomyl are available for homeowner use (Table 4), and are often recommended alternatives.

The commercial drupe or stone fruit industry (cherries, peaches, plums, prunes, nectarines and apricots), especially producers of sweet cherries, would be severely affected if captan registration were to be cancelled (12). The immediate impacts for producers of other stone fruits would be less severe; however, the long-term effects could be very damaging according to the assessment report. Most growers would have to rely on less effective fungicides such as dodine or on benomyl with its high incidence of disease resistance. The impact on the stone fruit industry could be even more severe if other compounds were also to have their registration cancelled. Thus, the impact on small fruit orchards could be substantial. These orchards could be several acres in size or more often, they consist of only a few trees. Captan is recommended in 11 states for home use to control stone fruit diseases since it has the advantage of being a broad spectrum fungicide effective in controlling the most common fruit tree diseases. In addition captan

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is available to the general public in container sizes that are appropriate for home use at a reasonable price. Benomyl often recommended as an alternative along with other fungicides could help fill the void but at a considerably higher price.

Data on impact of captan concellation on commercial small fruit production is not available. Captan is, however, recommended for home use to control diseases of grapes, blueberries, strawberries, raspberries and blackberries and is considered an integral part in home spray schedules.

Loss of captan as a foliar spray in commercial vegetable crop production would not be significant (3). Growers are currently using more effective compounds and basically are no longer using captan in foliar spray programs. Chlorothalonil and captafol have been shown to be more effective than the EBDC fungicides. Likewise, the removal of captan would probably not seriously affect home vegetable production since other recommended and registered compounds are available for vegetable disease control in the home garden. These fungicides include chlorothalonil, maneb, zineb and benomyl which can all be purchased by the homeowner (Table 4).

Cancellation of captan registration would seriously affect vegatable seed treatment. The ten largest vegatable seedsmen in the U.S. are uniform in their opinion that captan is unique and must be kept in registration since the only two efficacious registered alternatives, dexon and thiram either lack broad spectrum or are toxic due to irritating properties (8). The homeowner could be affected not so much because one could not treat one's own seed prior to planting,

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since current recommendations are to purchase treated seed, but rather that one would no longer be able to purchase treated seed any longer. Losses due to damping-off could thus be very severe often resulting in death.

Captan has been widely recommended for commercial ornamental disease control due to its broad spectrum labelling (11). The assessment report of captan use on ornamentals (11) is comprehensive; captan labels with ornamental use and alternative fungicides for captan use are all given. The conclusion from the assessment was that captan contains few fungicidal characteristics that would make its replacement difficult for ornamental disease problems when considered individually. However, if replacement compounds do not remain available, and registration and spectrum of activity are considered as well as availability, then captan loss would have an impact. Cost would also be a big factor since growers need a low priced product which can be used on a number of different crops. The effect of captan cancellation on homeowners would likewise be similar. Zineb, maneb, chlorothalonil and benomyl, commonly recommended alternatives for control of many ornamental diseases, are also available in small packages for homeowner use (Table 4).

The widest application of captan usage on commercial turfgrass is in the control of seedling diseases due to its low cost and broad spectrum of disease control activity. Captan is also used for control of Helminthosporium diseases, gray leaf spot, brown patch and copper spot. Loss of captan would not result in an increased severity of turfgrass diseases; however, the cost of seedling disease control on

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turfgrass could be increased (1). Homeowner use of captan is limited to occasional use such as in seedbed preparation in the planting of turfgrass seed or for spot treatment of diseases on established turf. Registered alternatives to captan for homeowner turfgrass disease control include benomyl, maneb, zineb, chlorothalonil and anilazine (Table 4).

IV. Summary

In summary, cancellation of captan registration could affect homeowners when disease control is warranted in the home and garden situation. Captan is currently registered for a wide spectrum of crops which include the most commonly grown fruit crops, vegetables, turf and ornamentals. It is registered and labelled for soil and drench applications, plant and product dips, and fruit and foliar sprays and for the most part is relatively non-phytotoxic. Homeowners who have invested money and time in their plantings seek to preserve the aesthetic beauty and productivity of their investments. Removal of captan could make disease control more difficult since in some cases alternative materials are less available, more costly or less effective.

could be processed (1). Processing [illegible] of cotton, in [illegible]

[illegible] such as [illegible]

or [illegible] [illegible]

[illegible] alternatives to [illegible]

[illegible] [illegible]

[illegible] V, consolidated, of certain [illegible]

[illegible] what disease control [illegible] useful [illegible]

[illegible] Capital is currently [illegible]

[illegible] include the work currently [illegible]

[illegible] It is registered and labeled [illegible]

[illegible] plant [illegible] product [illegible]

[illegible] part is relatively [illegible]

and time in these plantings [illegible]

and productivity of their [illegible]

[illegible] make disease control more difficult [illegible]

plots are [illegible]

Table 1. Registered and labelled Ortho lawn and garden products containing captan as the ingredient active as fungicide (5).

Table 1A. Ortho Home Orchard Spray (Captan 15% ai)

Crop	Diseases Controlled
Apricots/Cherries	Black Rot (fruit and leaf spots)
Apples	Bitter Rot, Black Rot, Black Pox Botryosphaeria, Brooks Fruit Spot, Fly Speck, Scab
Peaches	Brown Rot, Scab
Plums/Prunes	Brown Rot
Pears	Scab
Strawberries	Botrytis Rot
Grapes	Black Rot (fruit and leaf spot), Dead Arm

Table 1B. Orthocide Garden Fungicide (Captan 50% ai)

Crop	Diseases Controlled
Roses	Black Spot
Tuberous Begonias	Powdery Mildew
Carnations	Rust, Alternaria (leaf spot)
Chrysanthemum	Botrytis Flower Blight
Cuttings (Azaleas, Carnation, Chrysanthemum)	Damping-off
Bulbs (Gladiolus, Tuberous Begonias)	Rot, Damping-off
Lawns or Turf	Helminthosporium (melting out)
Tomatoes	Early and Late Blight, Gray Leaf Spot, Anthracnose, Septoria Leaf Spot
Mangoes	Cercospora Spot or Blotch
Apples/Pears	Scab, Fruit Spot, Bitter Rot
Peaches	Brown Rot, Peach Scab
Cherries	Cherry Leaf Spot, Brown Rot
Strawberries	Botrytis Rot
Oranges/Lemons/Limes/Grapefruit Tangerines	Brown Rot (Phytophthora)

Table 1C. Ortho Tomato Vegetable Dust (Captan 4.7% ai)

Crop	Diseases Controlled
Tomato	Septoria Leaf Spot and Anthracnose
Pepper	Anthracnose and Cercospora
Eggplant	Phomopsis, Alternaria and Anthracnose
Strawberries	Botrytis Rot
Raspberries	Spur Blight, Anthracnose and Fruit Rot

Table 2. Registered and labelled Stauffer product containing captan as the ingredient active as fungicide (13).

Captan Garden Spray (Captan 50% ai)	
Crop	Diseases Controlled
Carnation	Rust, Alternaria Leaf Spot
Chrysanthemum	Botrytis Flower Blight
Cuttings (Azalea, Carnation, Chrysanthemum)	Damping-off
Gladiolus	Rot, Damping-off
Tuberous Begonias	Rot, Damping-off
Lawns, Turf	Brown Patch, Damping-off, Leaf Spot, Root Rot
Cucurbits	Angular Leaf Spot, Anthracnose Downy Mildew
Potato	Early and Late Blight
Tomato	Early and Late Blight, Gray Leaf Spot, Septoria Leaf Spot
Apple	Scab, Fruit Spot, Sooty Blotch, Fly-speck, Fruit Rots, Frog-eye
Grape	Downy Mildew, Black Rot, Dead Arm
Peach	Brown Rot, Scab
Raspberry	Botrytis Fruit Rot
Strawberry	Botrytis Rot
Beans/Cabbage/Corn/Melons Peas/Squash	Seed Rot, Damping-off
Beets/Chard/Spinach/Grass	Seed Treatment

Table 3. Manufacturers, distributors and formulators of small-package pesticides which contain captan as the ingredient active as fungicide (7).

Manufacturer, distributor or formulator	Product name
Acme	Bulb Saver
	Fruit Tree Spray
	Rose Dust
Agway	Fruit Spray
	Garden Vegetable Spray
Black Leaf (also K-Mart)	Fruit Tree Spray
Ferti-Lome	Fruit Tree Spray
	Lawn and Fruit Tree Disease Control
Good-Life	Garden Spray
Hopkins	Fruit Tree Spray
Patterson's	Captan Garden Spray
	Fruit Tree Spray
Pratt	Fruit Tree Spray
Science Products	Fruit Tree Spray
	Garden Dust

Table 4. Small-package fungicides labelled and registered for home and garden use (7).

Manufacturer, distributor or formulator	Product name	Name of ingredient active as fungicide
Acme	All Around Dust	zineb
	Bordeaux mixture	lime + copper sulfate
	Lime Sulfur Spray	sulfur
	Phaltan 75W Fungicide	folpet
	Tomato and Vegetable Dust	zineb
	Zineb 75W	zineb
Agway	Ferbam 76W	ferbam
	Granular Turf Fungicide	anilazine
	Maneb 4,5-D	maneb
	Maneb-Sevin 4,5-D	maneb
	Rose and Floral Dust	folpet
Black Leaf (also K-Mart)	Fore	maneb + zinc
Ferti-Lome	Broad Spectrum Liquid	chlorothalonil
	Powdery Mildew Fungicide Control	copper oleate
	Rose and Ornamental Disease Control	folpet
	Rose Dust	sulfur
	Systemic Fungicide	benomyl
Hopkins	Potato-Tomato Dust	maneb
Ortho	Dormant Disease Control	calcium polysulfide
	Flotox Garden Sulfur	sulfur
	Funginex Rose Disease Control	triforine

	Lime Sulfur Solution	lime sulfur
	Liquid Lawn Disease Control	chlorothalonil
	Maneb 80 Fungicide	maneb
	Orthorix Sulfur	lime sulfur
	Phaltan Rose and Garden Fungicide	folpet
	Rose and Floral Dust	folpet
	Rose and Flower Jet Duster	folpet
	Vegetable Disease Control	chlorothalonil
Patterson's	Benomyl Systemic Fungicide	benomyl
	Bordeaux Mixture	lime + copper sulfate
	Tomato Dust	maneb
	Turf Fungicide with Dyrene	anilazine
	Zineb WP 75%	zineb
Pratt	Benomyl Fungicide	benomyl
	Bordeaux Mixture	lime + copper sulfate
	Lawn and Garden Fungicide	maneb
	Liquid Maneb	maneb
	Tomato and Vegetable Dust	copper
	Turf Fungicide	anilazine
Science Products	Fore Lawn Fungicide	maneb + zinc
	Gladiolus and Bulb Dip	thiram
	Rose and Floral Dust	folpet
	Rose and Garden Fungicide	folpet
	Tomato and Vegetable Dust	zineb
	Zineb Fungicide	zineb
Security	Lime Sulfur Solution	lime sulfur

Unico (Universal Cooperative)	Plant Spray Oil and Benomyl	benomyl

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